PROCEEDINGS

OF THE

IOWA ACADEMY OF SCIENCES

FOR 1904.

VOLUME XII.

EDITED BY THE SECRETARY.

PUBLISHED BY THE STATE.

DES MOINES:
B. MURPHY, STATE PRINTER
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LETTER OF TRANSMITTAL.

DES MOINES, IOWA, June 27, 1905.

To His Excellency, ALBERT B. CUMMINS, Governor of Iowa:

In accordance with the provisions of title 2, chapter 5, section 136, code 1897, I have the honor to transmit herewith the proceedings of the nineteenth annual session of the Iowa Academy of Sciences, and request that you order the same to be printed.

Respectfully submitted.

T. E. SAVAGE,
Secretary Iowa Academy of Sciences.

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*This paper was omitted from volume XI on account of lack of space.

OFFICERS OF THE ACADEMY.

1904.

President—B. SHIMEK.
First Vice-President—L. H. PAMMEL.
Second Vice-President—M. F. AREY.
Secretary—T. E. SAVAGE.
Treasurer—H. W. NORRIS.

EXECUTIVE COMMITTEE.

Ex-Officio—B. SHIMEK, L. H. PAMMEL, M. F. AREY, T. E. SAVAGE
H. W. NORRIS.
Elective—H. E. SUMMERS, C. N. KINNEY, G. E. FINCH.

1905.

President—M. F. AREY.
First Vice-President—J. L. TILTON.
Second Vice-President—C. O. BATES.
Secretary—T. E. SAVAGE.
Treasurer—H. E. SUMMERS.

EXECUTIVE COMMITTEE.

Ex-Officio—M. F. AREY, J. L. TILTON, C. O. BATES, T. E. SAVAGE
H. E. SUMMERS.
Elective—L. S. ROSS, C. L. VON ENDE, R. B. WYLIE.

PAST PRESIDENTS.

OSBORN, HERBERT........................1887-88
TODD, J. E 1888-89
WITTER, F. M.............................1889-90
NUTTING, C. C............................1890-92
PAMMEL, L. H.............................1893
ANDREWS, L. W............................1894
NORRIS, H. W.............................1895
HALL, T. P...............................1896
FRANKLIN, W. S...........................1897
MACBRIDE, T. H...........................1897-98
HENDRIXSON, W. S.........................1899
NORTON, W. H.............................1900
VEBLEN, A. A.............................1901
SUMMERS, H. E............................1902
FINK, BRUCE..............................1903
SHIMEK, B................................1904

MEMBERS OF THE IOWA ACADEMY OF SCIENCES.

FELLOWS.

ALDEN, W. C. .... Mount Vernon
ALMY, F. F. .... Grinnell
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BAKER, H. P. .... Ames
BATES, C. O. .... Cedar Rapids
BEGEMAN, L. .... Cedar Falls
BENNETT, A. A. .... Ames
BEYER, S. W. .... Ames
BUCHANAN, R. E. .... Ames
CALVIN, S. .... Iowa City
CLARK, J. F. .... Fairfield
CRATTY, R. I. .... Armstrong
CURTIS, C. F. .... Ames
DAVIS, FLOYD .... Des Moines
DENISON, O. T. .... Mason City
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ERWIN, A. T. .... Ames
FINCH, G. E. .... Marion
FINK, B. .... Grinnell
FITZPATRICK, T. J. .... Iowa City
GOODWIN, J. G. .... East St. Louis, Ill.
GOW, J. E. .... Greenfield
GREENE, WESLEY .... Des Moines
GUTHRIE, J. E. .... Ames
HADDEN, D. E. .... Alta
HARRIMAN, W. E. .... Ames
HENDRIXSON, W. S. .... Grinnell
HILL, G. H. .... Des Moines
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KINNEY, C. N. .... Des Moines
KNIGHT, N. .... Mount Vernon
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LORENZ, C. F. .... Iowa City
MARSTON, A. .... Ames
MACBRIDE, T. H. .... Iowa City
MARTIN, A. W. .... Indianola
MILLER, A. A. .... Davenport
MORRISON, EDWIN .... Oskaloosa
MUELLER, H. A. .... Winterset
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NORRIS, H. W. .... Grinnell

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PECK, MORTON E	Iowa Falls
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STOOKEY, S. W	Cedar Rapids
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VEBLEN, A. A	Iowa City
WALKER, E. R	Iowa City
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WILDER, F. A	Iowa City
WILLIAMS, I. A	Ames
WITTER, F. M	Muscatine
WYLIE, R. B	Sioux City

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AFFLECK, G. B	Cedar Falls
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ALLEN, A. M	Des Moines
BAILEY, B. H	Cedar Rapids
BARR, W. M	Grinnell
BELL, W. B	Iowa City
BIERRING, W	Iowa City
BOEHM, W. M	Iowa City
BOSWELL, MARY L	Davenport
BOUSKA, F. W	Ames
BRYDEN, C. L	Iowa City
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CARTER, CHARLES	Corydon
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LAMBERT, C. I .... Iowa City
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TREAT, DR. JOS. A .... Stuart
TREGANZA, J. A .... Britt
WALTERS, G. W .... Cedar Falls
WARREN, EDNA M .... Grinnell
WATKINS, H. R .... Ames

CORRESPONDING MEMBERS.

ANDREWS, L. W .... St. Louis, Mo.
ARTHUR, J. C .... Purdue University, Lafayette, Ind.
BAIN, H. F .... U. S. Geological Survey, Washington, D. C.
BALL, C. R .... Department of Agriculture, Washington, D. C.
BALL, E. D .... State Agricultural College, Logan, Utah
BARBOUR, E. H .... State University, Lincoln, Neb.
BARTSCH, PAUL .... Smithsonian Institution, Washington, D. C.
BEACH, S. A .... Geneva, N. Y.

BEACH, ALICE M	University of Illinois, Urbana, Ill.
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BRUNER, H. L	Irvington, Ind.
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COBURN, GERTRUDE	Kansas City, Kan.
CONRAD A. H	18 Abbott Court, Chicago, Ill.
COOK, A. N	University of South Dakota, Vermillion, S. Dak.
CRAIG, JOHN	Cornell University, Ithaca, N. Y.
DREW, GILMAN C	Orono, Maine
ECKLES, C. W	University of Missouri, Columbia, Mo.
FAUROT, F. W	Missouri Botanical garden, St. Louis, Mo.
FRANKLIN, W. S	Lehigh University, South Bethlehem, Pa.
FRYE, T. C	State University, Seattle, Wash.
GILLETTE, C. P	Agricultural College, Ft. Collins, Colo.
GOSSARD, H. A	Lake City, Fla.
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HITCHCOCK, A. S	Department of Agriculture, Washington, D. C.
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LEVERETT, FRANK	Ann Arbor, Mich.
MALLY, F. W	Hulen, Tex.
MALLY, C. W	Grahamtown, Cape Colony, South Africa
McGEE, W J	Bureau of Ethnology, Washington, D. C.
MEEK, S E	Field Columbian Museum, Chicago, Ill.
MILLER, B. L	Bryn Mawr, Pa.
MILLS, S. J	Denver, Colo.
NEWELL, WILMON	Capital Building, Atlanta, Ga.
OSBORN, HERBERT	State University, Columbus, Ohio
OWENS, ELIZA	Bozeman, Mont.
PATRICK, G. E	Department of Agriculture, Washington, D. C.
PRICE, H. C	State University, Columbus, Ohio
READ, C. D	Weather Bureau, Vicksburg, Miss.
REPP, J. J	Philadelphia, Pa.
SIRRINE, F. A	124 South Ave., Riverhead, New York
SIRRINE, EMMA	Dysart, Iowa
SPENCER, A. C	U. S. Geological Survey, Washington, D. C.
STULL, W. N	Mallinkrodt Chemical Co., St. Louis, Mo.
TODD, J. E	Vermillion, South Dakota.
TRELEASE, WILLIAM	Missouri Botanical Gardens, St. Louis, Mo.
UDDEN, J. A	Rock Island, Ill.
WEEMS, J. B	Alleghany, West Va.
WINSLOW, ARTHUR	Kansas City, Mo.
YOUTZ, L. A	New York City, N. Y.

Emma Pammel Hansen, B. S., M. S.

BY H. E. SUMMERS.

Perhaps we do not always give just credit to the influence exerted on the progress of science by those who devote themselves largely to the teaching, to elementary students, of those methods and fundamental conc pts upon a true appreciation of which their after development so much depends. Only a small proportion of beginners will become professional scientists, but every professional scientist was once a beginner, influenced for good or ill by the training then received. Furthermore, it is becoming more and more generally recognized that success in most occupations and also those qualities essential to good citizenship depend largely on conformity to the scientific method.

Perhaps it was in this direction that Mrs. N. E. Hansen, during her active membership in the Academy, exerted the most lasting influence. Her ability as an investigator, however, was clearly shown by studies, the results of which were published in the following papers:

"A comparative Study of the Leaves of Lolium, Festuca, and Bromus." Proceedings of the Iowa Academy of Science. 4: 126–131. pl. 9–11.

"A Contribution on the Gases produced by certain Bacteria", L. H. and Emma Pammel. Centralb. f. Bakt. Parastienk. u. Ifekt. II. ABT. 2: 633–600. Pl. 5.

Also some chemical papers published in the American Chemical Journal.

Miss Emma Pammel was born at La Crosse, Wisconsin, November 17, 1874. She prepared for college in the schools of that place and then entered the Iowa State College, from which she graduated in 1894. In her undergraduate course she was known as a really exceptional student, especially in scientific work. Her special interest was in Chemistry and Botany, and on her graduation she was appointed an assistant in the former subject, a position which she held for two years. She received her degree of Master of Science in 189?. Following this she was a teacher of Science in the East Des Moines High School for a year, and then held a similar position at Wahpeton, North Dakota. Her work as a High School teacher was discontinued upon her marriage in November, 1898, to Prof. N. E. Hansen of the University of South Dakota.

Her sad death occurred at her home in Brookings, South Dakota, December 16, 1904, at the early age of thirty. While this brought to an end her personal work in science, may we not hope and believe that her influence may live forever through the two children who now mourn her loss, but will in future remember her only with love and respect for the qualities for which they are indebted to her.

PROCEEDINGS

OF THE

NINETEENTH ANNUAL SESSION

OF THE

IOWA ACADEMY OF SCIENCES.

The nineteenth annual meeting of the Iowa Academy of Sciences was held in the chemistry lecture room of Iowa College at Grinnell, April 20 and 21, 1905. In the business session the following matters of general interest were acted upon:

REPORT OF THE SECRETARY.

TO THE MEMBERS OF THE IOWA ACADEMY OF SCIENCES:

At the last meeting of the Academy five names were added to the list of fellows. An equal number of fellows were transferred to the list of corresponding members, on account of their removal from the state. Nineteen associate members were elected at the last meeting, thirteen of whom have qualified. The present membership of the Academy consists of fifty-eight fellows, fifty associate members and fifty-one corresponding members; making a total of one hundred and fifty-nine.

During the past year the Academy has suffered the loss, by death, of one of the corresponding members, Mrs. N. E. Hansen of Brookings, South Dakota.

There is still need of a determined effort to increase our membership. Since the last meeting a circular letter, stating the purpose of the Academy and urging its advantages to persons interested in Science work and inviting such persons to apply for membership, has been sent to the teachers of Science in all the high schools of our state.

In our list of associate members there are a number of names which should be found among those of fellows. I would suggest that the committee on membership consider this matter, and make such recommendations with regard to transfers as they deem wise.

Notwithstanding the fact that our meeting last year was held about the middle of April, the printing of Volume XI of the Proceedings was completed before the end of August. Including the introduction and illustrations, this volume contained the full three hundred pages allowed by law, and one paper was held over on account of lack of space.

One serious cause of delay in the printing of our report is the tardiness with which the papers that are presented at the meeting are placed in the hands of the secretary. Of course the completed copy for the Proceedings can not be given to the printer until the last paper is submitted. I would very urgently request that all papers intended for publication in the Proceedings be handed to the secretary by the close of the meeting or, at the latest, within two weeks from that date.

In accordance with your instructions at the 1904 meeting, the different papers were so arranged in Volume XI of the Proceedings that the work of each author constituted a distinct article, by itself. The printer kindly agreed to furnish the Academy 100 extra copies of the Proceedings at the same rate that was paid for the 1,000 copies furnished by the state. From these 100 extra copies the different papers were extracted and stitched separately, and distributed as reprints to the various writers. In this manner the Academy was enabled to furnish to each author 100 separates of his paper at a cost of about forty-six dollars.

Respectfully submitted,

T. E. SAVAGE, Secretary.

REPORT OF TREASURER FOR 1904-1905.

RECEIPTS.

Balance from 1903-4	$113.68	
Back dues	12.00	
Annual dues, eighteenth meeting	58.00	
Initiation and transfer to fellows	25.00	
Sale of Proceedings, Part 1 of Vol. 1	1.00	
Sale of Proceedings other than Part 1	9.30	
Total		$218.98

EXPENDITURES.

Expense, postage, express, drafts, etc., treasurer			$ 7.72	
Expense, postage, secretary			7.90	
Printing, 500 letter heads, Ray & Cowden	$2.00			
200 receipt blanks, Ray & Cowden	1.25			
Total		$3 25		
200 preliminary programs 1905	$2.75			
100 final programs	1.50			
250 circular letters to science teachers	2.00			
100 membership blanks	1.25			
Total		7.50—	10.75	
Printing of Authors' Separates, B. Murphy			45.82	
Binding of Proceedings for members, H. Tedford			22.00	
Cash on hand			124.79	
Total				$218.98

H. W. NORRIS,
Treasurer.

Upon the recommendation of the membership committee the following transfers and additions were made to our list of fellows, associate members and corresponding members:

TRANSFERRED FROM ASSOCIATE MEMBER TO FELLOW.

A. T. Erwin, Ames; Wesley Greene, Des Moines; C. N. Kinney, Des Moines; A. A. Miller, Davenport; Edwin Morrison, Oskaloosa; F. J. Seaver, Mt. Pleasant; I. A. Williams, Ames.

ELECTED FELLOWS.

H. P. Baker, Ames; E. W. Rockwood, Iowa City; W. J. Teeters, Iowa City; A. G. Smith, Iowa City; Morton E. Peck, Iowa Falls; J. B. Coover, Ames; W. E. Harriman, Ames; A. A. Van Hyning, Des Moines; A. A. Bennett, Ames.

ELECTED ASSOCIATE MEMBERS.

Sara Nollen, Grinnell; C. L. Bryden, Iowa City; Geo. E. MacLean, Iowa City; Samuel J. Collett, Toledo; H. E. Ilsley, Iowa City; F. G. Robb, Winfield; Mary Griffith, Iowa City; O. M. Olson, Ft. Dodge; H. S. I. Rutledge, Ft. Dodge; L. G. Michael, Ames; J. W. Edwards, Mt. Pleasant; R. Monroe McKenzie, Fairfield; Chas. Aldrich, Des Moines; Naomi Ackenback, Marshalltown; G. B. Affleck, Cedar Falls; Dr. Joseph A. Treat, Stuart; Netta Anderson, Rock Island; Georgia Witter, Ames; Hon. Ellison Orr, Waukon; Estelle Fogel, Ames; W. G. Ross, Fairfield; F. L. Rainey, Fair-

field; Frances Carns, Newton; C. Guy Eldredge, Mt. Vernon; L. E. A. Ling, Cresco; L. D. Weld, Cedar Rapids; Mabel Clare Williams, Cedar Rapids; Dan F. Bradley, Grinnell, C. E. Seashore, Iowa City; Edna M. Warren, Grinnell; Miss Emma Johnson, Grinnell; Prof. J. H. T. Main, Grinnell.

CORRESPONDING MEMBERS.

A. N. Cook, Vermillion, S. D.; L. W. Andrews, St. Louis, Mo.; J. B. Weems, Alleghany, W. Va.

The membership committee, consisting of W. S. Hendrixson, H. W. Norris and T. E. Savage, was made a standing committee to act throughout the year in securing an increase in the membership of the Academy.

REPORT OF COMMITTEE ON RESOLUTIONS.

Your committee on resolutions begs leave to present the report following:

Resolved—First. That the Iowa Academy of Sciences, in Grinnell assembled, records an expression of grateful appreciation of the hospitality extended this Academy by the citizens of Grinnell.

Second. That the Academy recognizes its deep obligations to the members of the Faculty of Iowa College by whose efforts all local arrangements were made perfect for the use and convenience of the Academy.

Third. That the Academy is especially appreciative of the courtesy of President and Mrs. Bradley in opening the President's house to the reception of visiting members and fellows.

Your committee begs further to report the resolution following:

Resolved—That the Iowa Academy of Sciences records its sympathy in the effort of all those citizens of the state who are laboring to maintain the perpetuity of our various natural and meandered lakes, wherever these can be made to serve the beauty of Iowa landscapes, and the comfort, pleasure and recreation of our people.

S. W. Beyer,
Thomas H. Macbride,
C. O. Bates.
Committee.

The committee on secretary's report submitted the following recommendations concerning reprints, papers, etc., which were adopted:

1. That the secretary make the same arrangement as was made last year with regard to separates of papers, but that he be endowed with discretionary powers, after conferring with the executive committee.

2. That all papers for publication in the Proceedings should be submitted to the secretary within two weeks after the date of the annual meeting.

3. That all lists or purely catalogue papers should be printed in double column form.

4. That the Academy pay the secretary an honorarium of twenty-five dollars for the ensuing year.

L. H. PAMMEL,
L. S. ROSS,
FRANK F. ALMY,
Committee.

The following officers were elected for the ensuing year:

President—M. F. Arey.
First Vice-President—J. L. Tilton.
Second Vice-President—C. O. Bates.
Secretary—T. E. Savage.
Treasurer—H. E. Summers.
Elective Members of the Executive Committee—L. S. Ross; C. L. von Ende; R. B. Wylie.

The committee on pure food legislation was continued. Prof. L. G. Michael was made a member of the committee to fill the vacancy made by the removal of Prof. J. B. Weems from the state. The committee was authorized to elect its own chairman.

At the literary sessions the following papers were presented:

Presidential address, "Botany and Intelligent Citizenship."—B. Shimek.

"The U. S. S. Albatross and its Work."—C. C. Nutting. (Illustrated with lantern slides taken by the author.)

"Apparatus for Plating Out Petri Dishes in the Field."—L. S. Ross.

"Notes on American Cladonias."—Bruce Fink.

"Some Notes on the Flora of the Bitter Root Mountains of Montana."—L. H. Pammel.

"An Ecological Study of the Sabine and Neches Valleys, Texas."—James E. Gow.

(a) "Action of Bromic Acid on Metal." (b) "Determination of Bromic and Hydriodic Acids."—W. S. Hendrixson.

"A Study of a Thermophilic Bacterium."—R. E. Buchanan.

"J. J. Thomson's Theory of Matter."—L. Begeman.

"Variation in the Ray Flowers of Anthemis cotula and Other Composites."—H. S. Fawcett.

"Some Slime Moulds of New Mexico."—T. H. Macbride.

"Report on Some Iowa Birds."—B. H. Bailey.

"Different Methods of Determining Carbon Dioxide in Minerals and Rocks."—Nicholas Knight.

"Flora of Hardin County."—Morton E. Peck.

"Three Color Projection."—C. F. Lorenz.

"Some Notes on Certain Iowa Algæ."—Bruce Fink.

"The Biology of Bacillus Violaceous Laurentius."—Grace Roode Rueda.

"Plants New to the Flora of Decatur County, with Summary."—J. P. Anderson.

"The Morphology of Vallisneria Spiralis." (Illustrated.)—R. B. Wylie.

"A Problem in Municipal Warterworks for a small Town."—J. L. Tilton.

"The Liliaceæ of Iowa."—T. J. Fitzpatrick.

"The Flowering Plants of Henry County."—J. M. Lindly.

"The Storage Battery and Switchboard at Simpson College."—J. L. Tilton.

"An Annotated List of Iowa Discomycetes."—Fred J. Seaver.

"Northward Extension of the Lake Valley Limestone."—Charles R. Keyes.

"Geological Structure of the Jornada Del Muerto and Adjoining Bolson Plains."—Charles R. Keyes.

"Bisection of Mountain Blocks in the Great Basin Region."—Charles R. Keyes.

"A Laboratory Barometer."—A. C. Page.

"Cohesion of Liquids and Molecular Weights."—Edwin Morrison.

"Municipal Hygiene." Part I.—C. O. Bates.

"Some Bacteriological Analyses of Railroad Water Supplies."—L. H. Pammel and Estelle D. Fogel.

"Growth and Pigment Production of Pseudomonas Janthina."—Harry F. Watt.

PRESIDENTIAL ADDRESS.

BOTANY IN ITS RELATION TO GOOD CITIZENSHIP.

BY B. SHIMEK.

There are devotees of science who are impatient at every mention of any connection between their favorite branch and the every day affairs of men. There are those to whom purely scientific attainment is so sacred that any attempt to profane it with suggestion of profit or practical return is sacrilege. While we must admire the unselfish devotion which has prompted men to give their lives to scientific effort without hope or thought of material reward, we must also recognize the fact that the days of exclusiveness are past—that learning is no longer confined to the cloister of the monk or the den of the savant—and that the greater availability of means and methods of investigation, together with the prospect of practical application of scientific principles, have produced a thirst for knowledge which exists far beyond the walls of the laboratory. Men now seek results from every effort, and on all sides we find scientific principles applied to the profit and the material advantage of man. He employs them to combat disease; to add to his personal comfort and convenience; to preserve or increase the fruits of his labor; and for direct personal profit in the countless industrial pursuits in which these principles are applied.

Scientific truth is not so sacred that it can not serve for the improvement, the uplifting, the comfort and security of the human race. Upon its foundations are erected the temples of modern civilization; the search for it has re-

sulted in an intellectual renaissance; and the discovery of its treasures has produced that wonderful industrial development which marks the present age. The latter fact, unfortunately, has also resulted in a tremendous abuse of those natural resources which are everywhere being drained to meet the constantly increasing demands of industrial interests. Almost every community in the land bows down to the fetich of industrial and resultant commercial activity. Young men have been taught, by implication if not by direction, that money-making is the great goal of all ambition, and the result is a lowering of standards of public and private morals. Let a schemer propose the building up of a business enterprise in any community and, no matter how questionable the means or uncertain the methods by which the scheme is advanced, the public becomes its enthusiastic supporter on the ground that it will "bring business", and that men will secure employment.

It is not my purpose to decry activity in legitimate business or enterprise, but I do insist that the best citizen is not necessarily he who is most expert in the art of money-making, and that the enterprises and undertakings which are of the greatest value to the community are not those whose results can be measured by ordinary commercial standards. The desire for making money, and for booming business enterprises, so completely dominates our people that public opinion has frequently permitted the grossest violations of the laws of justice and common sense, if only business activity could be promoted. Sometimes this is due to ignorance, but more frequently it is an exhibition of the spirit which was manifested by the railway promoter who, desiring a portion of one of the parks in a large city in this state, sneeringly publicly declared that if the people wanted grass they could keep their parks, but if they wanted business they had to have railroads.

Again and again certain business enterprises have been represented as the hope and salvation of the communities

in which they were developed, and for the time being public interest centered in them, as though the prosperity of the community depended for all time upon their encouragement and support. And yet how often have industries so heralded resulted in ultimate failure, with possible great profit for the few, but loss and suffering for the many, besides so often entailing the depreciation of individual and public moral sense! In many cases these industries have been almost forgotten, yet they have left a curse behind them in the form of recklessly wasted resources. Our "business enterprise" has often cost us dearly.

A number of industries were dependent on the American bison, but the bison is no more. The products of the beaver gave employment to many men, but the beaver is fast disappearing. The pearl button industry revived the drooping business spirit of some of our own river towns, but clams are no longer found within our borders in sufficient quantity for profitable manufacture, and again disappointment and disaster are following in the wake of "business enterprise." The forests of this country were thought to be inexhaustible, and everywhere the hum of the sawmill was welcomed as the harbinger of prosperity. Yet today many of the great forest areas are reduced to barren wastes, and while a few private fortunes were piled up, suffering for the many stares us in the face; indeed, the increased cost of lumber is already working hardships. Only a few years ago a large part of the southern peninsula of Michigan was covered with splendid pine forests which grew upon the poorest soils. Today the forests are cleared, and there remains only a sandy, barren tract of stumpland which will not even sustain sheep! Other portions of the country have fared equally badly, and everywhere there has been the same reckless disregard of consequences. It has simply been a game of grab, and no thought was given to the morrow. No attempt was made to husband or perpetuate our natural resources, and in almost every case the result has been the killing of the goose that laid the golden egg.

But the loss of these resources is not the only calamity which has befallen us. So widespread was the idea that everyone was entitled to anything which was "public" that the land-grabber and the timber-thief came to be regarded merely as enterprising citizens, and the standard of public morals was lowered to such an extent that the courts and public opinion sustained various so-called "vested rights," even when they were secured through fraud and collusion. But to some extent there has been a public awakening, and even the cold-blooded, self-satisfied business man is beginning to turn to the scientist, asking that he save him from his own folly.

Science, through its discoveries, has stimulated business enterprise, and has, therefore, been largely responsible for the havoc which has sometimes followed in its wake,—but science must also come to the rescue and point out the rational means and methods by which the good things which we enjoy may be perpetuated for the benefit of our descendants.

No scientific branch is more intimately connected with our everyday lives than botany. To plants we owe, directly or indirectly, practically all our food, and much of the shelter and protection which we enjoy. Agriculture, horticulture, and countless industries owe their existence to plants, and are based on scientific botanical principles. To plants we are also indebted for the comfort and beauty of our surroundings, and in every relation and activity of life, from the cradle to the grave, we have more or less to do with them. These relations involve not only personal profit and private interests, but common weal and public welfare as well. It follows that a knowledge of plants—a knowledge of botany—will the better enable us to derive the greatest benefit from this close relation. It will enable us to perpetuate and utilize that which is useful, and to protect ourselves against that which is harmful. It will convince us that we must concern ourselves not only with immediate profit, but with future consequences.

FIG 1. Original pine woods. Sacramento mountains, New Mexico.

FIG. 2. Pine woods and saw mill. Sacramento mountains, New Mexico.
The beginning of the end.

FIG. 1. The cleared mountain slopes. Sacramento mountains, New Mexico. The end.

FIG. 2. Young *Pinus ponderosa* springing up on slope protected from fires and sheep. Sacramento mountains, New Mexico.

PLATE III.

FIG. 1. Native White Oak forest near Iowa City. Neither pastured nor burned.

FIG. 2. Native *Pinus strobus*, Dubuque county, Iowa.

PLATE IV.

FIG. 1. A gravelly hillside stripped of its forest. Shows beginning of erosion. Algona, Iowa.

FIG. 2. A loess hillside stripped of its forest and now deeply eroded. Near Iowa City.

In no case has there been a more wanton disregard of these consequences than in the treatment of our forest resources. Before the conscienceless greed of the individual, encouraged by the lack of appreciation and understanding on the part of the public, splendid forests vanished in a few years. Not only was there the legitimate cutting of timber for the sawmill, but enormous tracts were devasted by fire, sometimes through carelessness, oftener by design. Nor has the destruction of wood been the only resulting calamity. Our forests grew naturally upon the poorer soils. When they were cleared, the veneer of soil upon the clay and gravel ridges, and of alluvium upon the sandy river bottoms, was soon removed, and the clay and sand, often unfit for cultivation, were brought to the surface. The erosion which followed the clearing of the forest permitted the waters to run off rapidly from the surface, thus causing the disappearance of springs. It also filled the streams with sand and mud, and made their formerly clear waters turbid. The effect of this destruction was felt not only by the owner of the land which was thus denuded, but by all his neighbors, and the question became one not of individual rights, but of common good and public welfare. But information upon this subject so intimately connected with good citizenship was at first lacking, and as it gradually developed, it usually came too late to be of value in preventing wholesale destruction.

As we approach the danger line as a result of our past recklessness, public interest in this question grows more and more in intensity. Our citizens are beginning to cry out for the preservation of the remnants of our forests, and to cast about for means and methods by which forests may be restored and extended. They are seeking information upon the great question of conservation of forest resources, and the botanist has here an opportunity which should not be allowed to escape. Our citizens should be taught that the forest yields other than material products; that it is often most valuable when undisturbed; that it will grow upon soils which will produce but little

else,—the poorest of our lands; that it can easily be encouraged by keeping out ground fires, cattle and other destructive agencies, thus giving the seedlings, as well as larger trees, an opportunity to develop; that there is no section of our own state which will not successfully produce trees, and that by a little forethought we may insure to the coming generations a splendid heritage which will form the basis of material prosperity, and the means of mental and moral uplifting.

There are grave questions of public policy the solution of which depends upon a knowledge of the growth and influence of forests, and a full appreciation of which is impossible without a knowledge of the fundamental principles of tree growth and treatment on the part of the citizens who must ultimately solve these problems. What shall be done with the great arid tracts in the western part of the country? The citizens of the interested sections are clamoring for government aid to their plans of irrigation, yet they are rapidly destroying the forests on the mountains which, in many places, alone insure a sufficient water supply. What shall be done with denuded tracts in more favored sections of the country, to prevent lasting injury to our streams? Shall this be left, as heretofore, to the neglect and selfishness of individuals?

There are questions involved in the parking of streets, establishment of parks and forest reserves, in the preservation of birds and game, etc., which must be settled by our citizens. Shall this be done intelligently? These questions can not be solved by a few enthusiasts, they must be met by an intelligent public, aware of the errors of the past, and educated to an appreciation of the possibilities of the future. And this campaign of education can, and should, be carried on in large part by the teachers of botany in the public schools and the colleges of our country.

APPARATUS FOR PLATING OUT PETRI DISHES IN THE FIELD.

BY L. S. ROSS.

For some time bacteriologists interested in water or sewage analysis have realized the fact that for determining the number of bacteria per c.c. the water should be plated as soon as possible after it has been collected. If the samples are collected at some distance from the laboratory, recourse is had to packing in ice, which is always cumbersome and sometimes very inconvenient. Even then results will not be so accurate as those obtained by plating immediately after collecting. Various attempts have been made to plate dishes in the field, I believe without very satisfactory results, until last summer when I first used the apparatus here described.

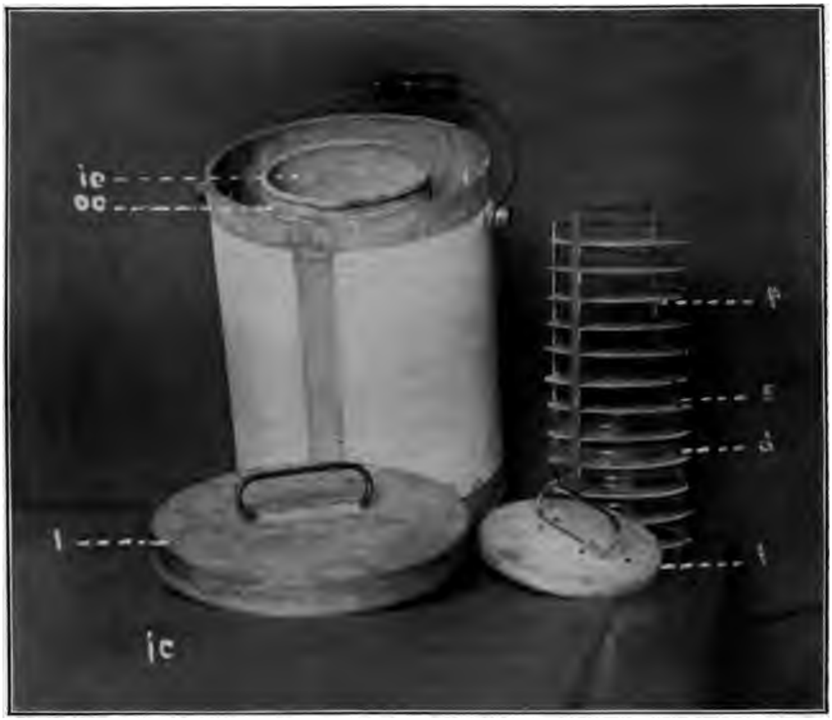
The refrigerator pail is a double walled galvanized iron or copper pail of sufficient size for a rack, holding Petri dishes of regulation size, to stand within the inner compartment. The outer compartment has an inside diameter of eight inches, the inner a diameter of about four and three-eighths inches. A rack holding twelve Petri dishes is made of three upright supports, and platforms upon which to set the dishes. Thin, circular metal plates four and one-fourth inches in diameter, for the reception of the dishes, are fastened to the uprights, a space three-fourths inch or more being left between any two plates. A long, straight spring is soldered to one of the upright supports for holding each dish in position by pressing firmly upon the cover. The end of the spring overlaps the edge of the dish and is bent at right angles to prevent the dish from slipping from its place upon the platform. A lid fits

upon the inner compartment of the pail which contains the dish rack. Also a flat lid fits over the entire pail. The bail is fastened to two small open tubes that project from the side of the pail a little distance below the top of the inner compartment. The outside of the pail is covered with asbestos paper or felt.

For work in the field it is necessary to carry a small bag containing tubes of gelatine and agar, a cylinder of pipettes, an alcohol lamp, collecting bottles and perhaps a small tin can. The outer compartment of the pail is packed with broken ice. The sterilized Petri dishes are placed in the rack. Upon collecting the water the plates are poured and are at once replaced in the rack where the gelatine very quickly solidifies. A small hand level may be used for leveling the pail by placing it upon the flat lid; the pail being blocked up with sticks or anything convenient. The gelatine will now have an equal depth in all parts of the dish. The plated samples may then be taken to the laboratory at the leisure of the worker, he knowing there will be no multiplication of bacteria or diminution of numbers.

The apparatus is primarily for use in warm weather but will be found convenient for cooler weather also. It may be used in the laboratory for solidifying plates, if there is no ice box convenient, by turning a stream of cold water into the outer compartment. The water does not get into the inner compartment because the outlet tubes are at a lower level than the top of the compartment. The pail may be made for six, twelve, or more dishes, as seems most desirable.

PLATE V.



Legend—*ic*—inner compartment.
oc—outer compartment.
r—dish rack.
s—spring to hold dish in position.
d—Petre dish in rock.
ll—lids of inner compartment and of pail.

A METHOD FOR THE DETERMINATION OF HYDRIODIC AND HYDROBROMIC ACIDS.

BY W. S. HENDRIXSON.

About a year ago I presented to the Iowa Academy of Sciences a paper on a method of determining chloric acid by the reduction of the acid with metallic iron in the presence of dilute sulphuric acid, and the titration of the hydrochloric acid formed, by the method of Volhard. The same paper, somewhat extended, appeared in another periodical.* In this communication it was suggested that the method might probably be used equally well for the determination of bromic and iodic acids, and two determinations of bromic acid were included in the paper.

Early in the present academic year the study of the action of metallic iron on bromic and iodic acids, with a view to the determination of the acids, was taken up with the results that follow in this paper.

Of course there could be little doubt that iron in acid solution would completely reduce both these acids giving their equivalents in hydrobromic and hydriodic acids, but since these are both strong reducing agents, they might be expected as soon as formed to react with the iodic and bromic acids remaining, with the liberation of six equivalents of bromine or iodine, according to well known reactions. The question to be settled really was, whether the iodine and bromine thus liberated would be readily changed at low temperature to the corresponding hydriodic and hydrobromic acids, so as to avoid any loss of iodine or bromine by volatilization.

* American Chemical Journal, Vol. 32, p. 242.

Determination of Iodic Acid.—As the basis for the work on iodic acid there was used a tenth normal solution of potassium iodate, made from an excellent sample by Merk, as the following determinations indicate. Portions of 20 c.c. of the decinormal solution were digested with potassium iodide and hydrochloric acid in a well stoppered bottle in the usual way, the solutions of free iodine thus obtained were made up to known volumes and portions were titrated with standard decinormal sodium thiosulphate:

(1) 20 c.c. of iodate solution gave iodine which required 120.32 c.c. thiosulphate.

(2) 20 c.c. of iodate solution gave iodine which required 120.40 c.c. of thiosulphate.

As well known it is practically impossible to obtain commercially, potassium iodide free from iodate. In the above experiments five grams of iodide were used in each case. The same weight of the iodide digested with hydrochloric acid gave free iodine which required 0.30 c.c. of thiosulphate. Applying this correction the volumes of thiosulphate required in experiments (1) and (2) are 120.02 and 120.10, while the theory for a truly decinormal solution of potassium iodate would require 120 c.c.

In the determination of both iodic and bromic acids, the iron in the form of washed card teeth, and 25 c.c. of dilute, pure sulphuric acid and a measured volume of the solution to be determined were placed in a distilling flask with a well-ground glass stopper. The side-tube of the flask was placed in a small quantity of water in a test tube in order to condense and make apparent any iodine or bromine that might pass over. At first in the experiments with iodate, alcohol was used to absorb the iodine, but water was substituted after it was found that with proper regulation of the temperature the amounts of iodine or bromine that passed over were practically negligible. On placing the substances together in the flask iodine was at once liberated, and considerable quantities soon settled upon the bottom of the flask. At room temperature the

vapor of iodine was not observed to rise above the bulb of the flask, but the complete conversion of the iodine into hydriodic acid required at room temperature three or four hours. If, however, the bulb of the flask was immersed in water kept at 50° it was found that the reaction went on much more rapidly and was completed in about one hour. Even at this temperature very little iodine came over, and this small quantity was, near the end of the experiment, returned to the flask by removing the flask from the water so that the liquid in the test tube and the wash water sucked back into the flask. The experiment was allowed to continue till all trace of the color due to iodine had disappeared and the liquid showed only the clear, light green color due to ferrous iron.

In the five following experiments the hydriodic acid formed was determined, after oxidizing the iron in solution to the ferric condition, by titration with a twentieth normal solution of silver after the method of Volhard. The silver solution was added in excess, the silver iodide was filtered off and the excess of silver was determined in the filtrate, with sulphocyanate.

(1) 10 c.c. iodate solution required 20.00 c.c. silver solution.

(2) 10 c.c. iodate solution required 19.90 c.c. silver solution.

(3) 20 c.c. iodate solution required 40.07 c.c. silver solution.

(4) 20 c.c. iodate solution required 40.10 c.c. silver solution.

(5) 20 c.c. iodate solution required 39.75 c.c. silver solution.

The solution obtained on oxidizing the iron was not perfectly colorless, and the color interfered somewhat with the titration with sulphocyanate. The best results were obtained when the solution was boiled to free it from nitrogen oxides and then allowed to stand till quite cold. Since it is questionable whether by Volhard's method it is permissible to determine halogens by titrating the excess

of silver without filtering off the silver halides it seems best to escape the disadvantage of titrating a colored solution by weighing the silver halide direct. In the following experiments the hydriodic acid was precipitated as silver iodide which was weighed.

(1) 20 c.c. iodate solution gave .4726 grams AgI, corresponding to .2554 grams iodine.

(2) 20 c.c. iodate solution gave .4764 grams AgI, corresponding to .2566 grams iodine.

(3) 20 c.c. iodate solution gave .4764 grams AgI, corresponding to .2574 grams iodine.

The theory requires .2539 grams iodine for 20 c.c. of the solution.

Determination of Bromic Acid.—The potassium bromate used in the following determinations was made by Merk. It contained no bromide. It was dried to constant weight at 100°. A deci-normal solution was made up and its strength was determined by digestion with hydrochloric acid and potassium iodide. 20 c.c. of this solution gave on digestion an amount of iodine which required 120.08 c.c. of a standard solution of sodium thiosulphate, deci-normal, while the theory for 20 c.c. of a normal solution of the bromate would require 120 c.c. of deci-normal thiosulphate.

The reduction with iron was carried out as already described under iodic acid, but it was found better to keep the solution at room temperature. In this case the complete reduction required about two hours. Usually no color of bromine was visible above the bulb of the flask, and care was taken to prevent the escape of any bromine by the same means as in the case of iodine. The amount of iron dissolved made it even more difficult than in the case of hydriodic acid, to use the Volhard method. Three determinations by this method gave results decidedly too low; and in fact, in three experiments in each of which 20 c.c. of bromate were used the volumes of silver used were 39.11, 39.35 and 39.07 c.c.

In the following experiments the hydrobromic acid was precipitated as silver bromide which was weighed:

(1) 20 c.c. bromate solution gave .3753 grams AgBr, corresponding to .1596 Br.

(2) 20 c.c. bromate solution gave .3764 grams AgBr, corresponding to .1603 Br.

(3) 20 c.c. bromate solution gave .3741 grams AgBr, corresponding to .1593 grams Br.

(4) 20 c.c. bromate solution gave .3758 grams AgBr, corresponding to .1599 grams Br.

The theory requires .1599 Br.

The method described seems to serve equally well for chloric, bromic and iodic acids. It is simple and direct, requires no specially constructed apparatus and in case one determines the hydrochloric, hydrobromic or hydriodic acid gravimetrically it requires no standard solutions.

Iowa College, Grinnell, Iowa, April 15, 1905.

NOTES ON AMERICAN CLADONIAS.

BY BRUCE FINK.

Since our western hemisphere surpasses the eastern in number of species and varieties of Cladonias and in forms peculiar to the hemisphere, the genus should have a special interest for the American student of lichens. Nevertheless our American descriptions have been for the most part quite inadequate and many of our determinations consequently incorrect. Cladonias are the most variable of all our higher lichens and therefore the most difficult to describe definitely. The most variable characters are those which may be studied with the eye or with a good hand lens, yet the most careful observation, the best possible descriptions, and comparison with authentic specimens are all necessary to enable one to determine these plants with any degree of certainty. Size, form, color, lobing and branching and the presence or absence of cortex and soredia must be constantly kept in mind in the consideration of the horizontal thallus, and yet more in the study of the podetia.

In actual determinations of Cladonias, the microscope need scarcely be used, except in instances where it is necessary to examine the thallus structure or the spores to make certain that one has not some species of such closely related genera as Baeomyces, Stereocaulon or Piloporus rather than a Cladonia. It is true that E. Wainio in his excellent Monograph, has seen fit to give a minute description of each species, even including the minute anatomy of the thallus of each species in great detail, but our investigations indicate that these characters of minute morphology are so constant, in the Cladonias, as to be only

very rarely of actual use in determinations. The so-called hypothallus is seldom seen and is of no use in the determination of Cladonias, while those doubtful structures, the spermagones and the spermatia, may be likewise neglected. As to chemical tests, it is extremely doubtful whether they are of diagnostic value in any lichens; and in the Cladonias, even the spore characters are so constant that they may be neglected. Here is a condition favorable to the work on the Cladonias, and it must be added that there is not another lichen genus in which microscopic characters may be largely neglected in determinations. However, the Cladonias are a comparatively recent evolution, and the macroscopic characters are so extremely variable and the preserved connecting links so numerous that the determinations are extremely difficult. Indeed, instead of being able to trace anything like a continuous line of evolution or even an evolutionary tree, the best students see only an interminable network of forms.

With all due respect to the late, eminent American lichenist, Tuckerman, it must be apparent to all who have attempted to use his diagnoses of American Cladonias as aids in determinations, that they are too brief and indefinite. For instance, Tuckerman recognizes in his manual just two varieties of *Cladonia fimbriata*, disposes of the species in a half page, and gives not the slightest hint that the forms are extremely varied and difficult to understand. This view is, however, all that could be expected from one who was a pioneer in the study of American lichens, and much as Tuckerman has done for American lichenology, we can not afford to do otherwise than pass beyond his results as rapidly as may be done with some sufficient degree of certainty.

In a series of articles now appearing in the Bryologist, the present writer is attempting to give a more recent view of the Cladonias by means of adequate descriptions, illustrations and notes on distribution. However, this work is merely preliminary in nature and much remains to be done in way of actual examination of material in

various herbaria and further collections and studies in American Cladonias. If the series of articles is found helpful in contributing to this end, they will serve their purpose. In passing beyond the Tuckermanian view, we have been so fortunate as to have the aid of the eminent Cladoniologist, E. Wainio, of the University of Helsingfors, and we now have his view of more than two hundred specimens of American Cladonias, which the present writer has submitted to him from time to time.

Attention was directed to the extremely great amount of variation in forms of *Cladonia fimbriata* years ago in work in the field, and an especial effort was made to obtain all of the forms possible. But it was only by a careful study of the species, as viewed by Wainio, and set forth in great detail in one hundred and three pages of his monograph of the genus Cladonia, that the present writer began to realize something of the difficulties to be encountered in the attempt to gain anything like an adequate knowledge of the species. In Wainio's monograph, sixteen varieties and a very large number of subvarieties and forms are recognized. We have not been able to see the subvarietal distinctions in some instances even with specimens which have passed through Wainio's hands before us. However, though we may not be able to follow the specialist in the genus into all of the intricacies of the most minute and discriminating observations, we have tried to improve matters somewhat, and perhaps as much as is desirable, by giving brief and yet sufficiently definite descriptions of the twelve varieties which are well known to exist in North America.

After *Cladonia fimbriata*, perhaps *Cladonia furcata* and *Cladonia crispata* are as troublesome as any of the Cladonia species. However, Tuckerman, in his treatment of the various forms of these two species, came much nearer to a correct solution than he did with regard to *C. fimbriata*. Indeed, though *C. furcata crispata* of Tuckerman's "Synopsis" has seemed difficult to trace, and though *C. furcata pungens* has seemed hardly to belong with the

2

species, yet the disposition has been as a whole fairly satisfactory. Wainio has seen fit to remove the latter variety from the species, placing it with *Cladonia rangiformis*, and this appears surely to be an improvement. The former variety Wainio has also removed from the species under the name, *Cladonia crispata*. This species as viewed by Wainio seems to be well represented in Europe, where there are quite a number of varieties. However, in America, we have as yet only two of the varieties, and there is room for doubt as to whether it is best to consider these forms as distinct from *Cladonia furcata*. Indeed, our *Cladonia crispata infundibulifera* seems very near to *Cladonia furcata paradoxa*, and further study is necessary to decide whether Wainio's view is the best one. But though there may be some doubt as to the best disposition of the puzzling *Cladonia crispata*, the study of the Minnesota Cladonias has brought to light one new variety within the two species, two others not previously known in North America, and still another known only through a single specimen collected many years ago by Tuckerman.

We may now consider *Cladonia gracilis*. The species has been abused in being subjected to the "splitting process" by European workers, but Wainio has succeeded in bringing order out of the chaos of names, and one who has learned to use his Monograph finds comparatively little trouble in applying his revision to our American forms of the species. The present writer thought years ago that *Cladonia gracilis* was the most difficult of all our Cladonias, but further acquaintance with *Cladonia fimbriata* gives that species first place as a difficult one.

It now appears plainly enough that much of the difficulty with *Cladonia gracilis* was really due to an attempt to follow Tuckerman, who included *Cladonia verticillata* with the above species. Then, too, *Cladonia gracilis symphycarpia* has been parceled out by Wainio to *Cladonia cariosa* and *Cladonia subcariosa*. Tuckerman gave his variety this description, "cups obsolete and apothecia confluent," and this diagnosis was wholly inadequate so that no one could

PLATE VI.

FIG. 1. *Cladonia fimbriata coniocræa* (Flk.) Wainio. X 2.

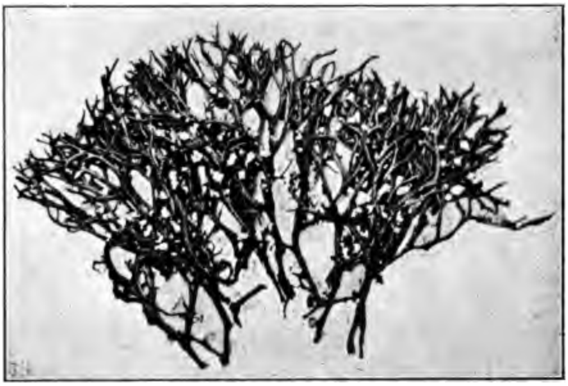


FIG. 2. *Cladonia furcata.* X 1.

conceive what he meant without seeing the specimens. This Wainio has done and has no doubt placed the forms where they belong. Indeed, it is apparent enough after Wainio has done the work, that Tuckerman's diagnosis would apply to a form of *Cladonia cariosa* or to one of *Cladonia subcariosa* quite as well as to *Cladonia gracilis.*

Is it any wonder that we could never understand *Cladonia gracilis* while attempting to follow Tuckerman who placed forms of at least four species in one?

In treating *Cladonia gracilis*, the writer considers himself exceedingly fortunate in being able to see the specimens collected by Mr. G. K. Merrill, on Mount Washington, N. H., during the last summer. Indeed, but for the keen-eyed work of this collector in this best American collecting ground for the species, we could by no means give the presentation which appeared in a recent number of the Bryologist.

It should be stated regarding *Cladonia gracilis* that the eastern forms are as a rule longer and more slender than the western. This appeared plainly enough in comparing the plants collected by Mr. Merrill with those found by the present writer in Minnesota and in Iowa. Also, Dr. L. H. Pammel has collected a form of *Cladonia gracilis elongata* in Montana, which inclines to the shorter form, but still seems to be the variety. Also, Tuckerman states that the plants are paler in lower latitudes as in lower portions of Maine, Massachusetts and California. Our forms from Minnesota are paler than those of Merrill from New England, but it appears also that forms of *Cladonia amaurocraea*, quite elongated and cup-bearing, have frequently been placed under *Cladonia gracilis.*

As indicated above, there is some real difficulty in distinguishing between *Cladonia gracilis* and *Cladonia verticillata.* During the last summer, Dr. E. T. Harper collected and photographed lichens on Isle Royale, in Lake Superior, and the present writer is under obligations to him for the photographs from which the plate presented herewith was made. This plate shows forms of the two closely related

species. In *Cladonia gracilis* the squamules are to be looked for anywhere on the podetia, while in *Cladonia verticillata* they occur very rarely, and, when present, are found only at the bases of the podetia or on the margins of the cups. Also in the latter species, the proliferations are almost always from the center portions (or cavities) of the cups, while in the former they are almost always from the margins. Such are the "ear marks," while other differences are less marked, and are difficult to bring out even in descriptions.

In attempting, thus briefly, to give some view of the work that is being done on the American Cladonias, we have selected for discussion some of the species that have been treated more at length, with descriptions, in the series of articles by the present author and now appearing in the Bryologist. The descriptions can not be repeated herein, but may be seen by any who may be interested.

Besides E. Wainio, another European who has helped considerably in the work on American Cladonias, is Mr. L. Scriba, of Hochst, Germany. Mr. Scriba aided the present writer several years ago and is now examining specimens sent him by Mr. G. K. Merrill.

To the person who wants all rough places made smooth and all disagreement and all uncertainty removed, the study of Cladonias is an aggravation. But the one who will not quail before a task that seems so large and so uncertain that he may never hope to complete it, will find in the genus a good field for the most discriminating taxonomic effort.

Only twenty-four forms of Cladonias have been reported from Iowa, while more than sixty are recorded for Minnesota. Our flora is not so rich in these plants, but there is a great need of careful collecting, examination of all material in the various herbaria of the state, and final revision of the work.

Thanks are due to the Bryologist for the cuts from which the accompanying figures are reproduced.

PLATE VII.

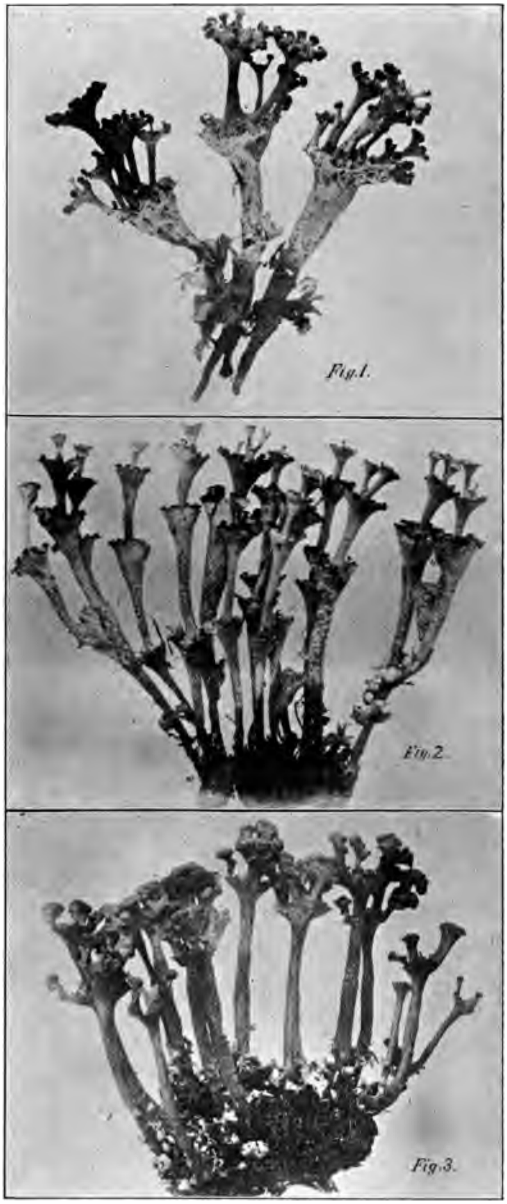


FIG. 1. *Cladonia verticillata.*
FIG. 2. *C. verticillata* var. *evoluta.*
FIG. 3. *C. gracilis* var. *dilatata.* X 1.

SOME NOTES ON CERTAIN IOWA ALGÆ.

BY BRUCE FINK.

Aside from the list by Bessey in 1884, the few algæ mentioned by Shimek (Proc. Ia. Acad. Sci. 4:80, 1896), and the article on diatoms by Myers (Proc. Ia. Acad. Sci. 6:47, 1898.) the present writer finds nothing in print regarding the algæ of Iowa. Surely this condition is not due to the fact that algæ have not been observed frequently enough, for the plants are so interesting that the student of aquatic flora always stops to study them as thoroughly as time at hand will permit.

The observations made by the present writer extend through thirteen years, eleven at Fayette and two at Grinnell. At no time during all these years has he been able to command time for a thorough study of the algæ of the two local floræ, and the time has not arrived for an attempt at a catalogue of some one hundred species and varieties observed in the two localities. However, a number of interesting forms have been observed, and some of the species have not been recorded for the state. Before proceeding further, however, thanks are due to two students for studies, under direction, which have aided materially in the work. Miss Carrie Greene spent some time in the study of the fresh water algæ in the vicinity of Fayette during the college year of 1901 and 1902, and Miss Louise Miles has aided in the work on the algæ in the vicinity of Grinnell.

As to the conditions about the two places, the one at Fayette has the advantage of the small stream known as the Volga river with its numerous springs, tributary creeks

and ox-bows. Besides these there are a considerable number of ponds. The forms from Fayette, not yet fully studied, are preserved in formalin and await further investigation. Grinnell lies in a region covered by the very old Kansan drift and on a divide between the Mississippi and Missouri rivers. High elevation and long time have combined to give a drainage system so perfect that ponds, other than artificial, are scarcely known in the region thus far studied, lying near the city. However, five artificial bodies of water lie within a mile of the place. A beginning of investigation of these has been made, and the present intention is to continue the study of the plant plankton, carefully noting the increase in number of species of algae in these new artificial bodies of water from year to year. The streams near the city are all small creeks, but the work could in time easily be extended to the Skunk river region, ten miles away.

No special attempt has been made to determine the diatoms and desmids, but besides the usual simple forms, a number of species consisting of stalked or filamentous colonies have been observed. *Cosmarium leve* Rabh. was a common form at Fayette, and other species of this genus and several forms of Closterium were frequently seen in both localities.

Two species of Coleochaete, one thalloid and the other filamentous, were collected at Fayette. The thalloid species we have provisionally called *Coleochaete scutata* Breb., while the filamentous form seemed to be *Coleochaete soluta* Pringsh. The species of this genus are of special interest on account of their relationships with higher land plants as shown in the segmentation within the ovary previous to the formation of the zoospores and in the passage from filamentous to thalloid forms. Therefore, these plants are of special interest for class work, but it may well be doubted whether anyone has ever found any species in sufficient quantity for that purpose in the state. No previous report of Coleochaetes in Iowa has been made.

Three species of Oedogonium have been collected in the two localities, but the specific names are reserved for further study. *Draparnauldia plumosa* (Vauch.) Ag. is frequent at Grinnell and at Fayette, and *Chaetomorpha pisiformis* (Roth.) Ag. and *Chaetomorpha cornudamae* (Roth) Ag., occur at Fayette, the last species being new to the state. A species of Stigeoclonium was kept in the college aquarium at Fayette for two years. The plant failed to produce the zoogonidia, but in all respects the vegetative structure agreed with *Stigeoclonium nanum* (Dillw.) Kg., a plant not previously reported from Iowa. The same species has been found clinging to the limestone riprap in Arbor lake at Grinnell, and another form has also been found in the lake, provisionally referred to *Stigeoclonium radians* Kg.

The polymorphous *Cladophora glomerata* (L.) Kg. is a common plant in the Volga river at Fayette, var. *genuina* Kirchn. occurring on stones in rapids and the varieties *rivularis* Rabenh. and *pumila* Bail. occurring in more quiet water. The three varieties have not been previously reported from Iowa. During the second summer after its construction (1904), the artificial Arbor lake at Grinnell became so filled with *Cladophora fracta* (Dillw.) Kg. as to interfere seriously with boating. The outing club spent a considerable sum in dredging without more than alleviating the difficulty, but in August or September the plant disappeared so completely that diligent collecting and microscopic examination of many filamentous algæ brought to light only one or two specimens of this particular species of Cladophora. At the present time, April 21, 1905, there is no evidence of the plant in the lake, and it may well be doubted whether it will again appear in any considerable quantity. However, if it should, the copper sulphate treatment will be tried. *Cladophora fracta rigidula* (Kg.) Rabenh. occurred with the species and has not been hitherto reported in Iowa. Two other Cladophoras were collected at Grinnell, one of which has been provisionally referred to *Cladophora crispata* (Roth.) Kg.

One or two species of Ulothrix and several of Conferva have been collected in the two places, but the determinations are so uncertain in the present state of knowledge of these genera that the specific names are omitted, except *Conferva (Microspora) vulgaris* (Rab.) Wolle and *Conferva (Microspora) amoena* Kg., which have been identified at both places, and are new to the flora of the state.

The Vaucherias common to both places are the common species, viz. *Vaucheria sessilis* (Vauch.) DC., *Vaucheria geminata* (Vauch.) DC., and *Vaucheria terrestris* Lyngb. These species are quite common in both localities and have been previously reported from Iowa. But *Vaucheria aversa* Hass. and *Vaucheria geminata racemosa* (Vauch.) DC., found at Fayette, have not been previously reported for the state.

Closely related to the Vaucherias is the cænocytic *Botrydium granulatum* (L.) Grev. The plant has only been reported from the vicinity of Ames, but is common on damp soil everywhere in the state. It is easily found along ponds, lakes and streams after one has once detected the minute globular, greenish, whitish or reddish forms on the soil, commonly occurring as the first plant of the society of a recently formed mud flat, and later with *Vaucheria terrestris*. The plant is an exceedingly interesting one for laboratory study, readily yielding the uniciliate and the biciliate zoogonidia, the latter also frequently conjugating when they are to be regarded as zoogametes. By placing the plants in a tumbler of water at night, these motile bodies always collect on the side toward the light, and if the habitual formation of them at night is retarded by keeping the plants cold by the use of ice, the zoogonidia and zoogametes may be studied in the forenoon. The stages of lateral and end-to-end conjugation may be studied readily, and the cilia may be brought out by killing and staining. The plant is especially interesting since we have here the very beginning of sexuality. Also, besides the conjugation of the zoogametes, we were able at Fayette to ascertain that the cænocytic mass sometimes, instead of form-

ing the ciliate motile bodies, breaks up into a large number of minute amoeboid masses, which frequently coalesce after the manner of the gonidia of smuts. The pale reddish motile cells of the red condition of the plant were also studied in the laboratory at Fayette, and were found to be somewhat more slender and elongated and more changeable in form than the forms produced from the more common green condition of the plant.

Volvox globator (L.) Ehrenb. and *Eudorina elegans* Ehrenb. were both collected in ponds at Fayette during the summer of 1902, the latter being new to the flora of the state. Besides these two specimens, there has occurred frequently in both localities compact brownish colonies, about the size of a *Pandorina morum* colony, with individuals densely packed in the spherical colonies and considerably elongated.

It may well be doubted whether Euglenas should be reported as algæ, but besides the common *Euglena viridis* (Schrank) Ehrenb., the exceedingly rare *Euglena spirogyra* Ehrenb. was discovered in the college aquàrium at Fayette, in October 1899. It multiplied rapidly until it gave the water the characteristic greenish color, and remained in larger or smaller numbers for more than a year. The organisms are more elongated than the ordinary *Euglena viridis*, are less changeable in form and show, at maturity, the spiral bands of chlorophyll very plainly. *Euglena spirogyra* has not been previously reported from Iowa, if indeed from any American locality.

A form of Pediastrum was frequently noted at Fayette, but the species has not been determined. *Hydrodictyon reticulatum* (L.) Lagerh, was only collected in the Volga river at this place two or three times. *Scenedesmus quadricauda* (Turp.) Breb. is very common at both localities and var. *abundans* Kirchn. is quite as common. *Scenedesmus obliquus* (Turp.) Kuetz. and the variety *dimorphus* (Turp.) Rabenh. are also quite common at Fayette. None of these species of Scenedesmus have been previously reported from the state.

Another series of closely related species is found at both places. These species are *Pleurococcus vulgaris* Menegh., *Protococcus viridis* Ag. and *Trentepolia* (*Chroolepus*) *umbrina* (Kuetz.) Born. Of these the last, rare outside of lichen thalli, is to be looked for especially on oak trees and has not been reported before from the state. The lichen, *Lepra viridis* Schaer, is much more common than the Pleurococcus, and appears exactly like the alga until careful microscopic examination reveals the fungal hyphæ in close relation with the algal cells. Thus this lichen commonly passes for *Pleurococcus vulgaris.* Another similar lichen is *Amphiloma lanuginosum* (Ach.) Nyl. (*Pannaria lanuginosa* Kbr.), but this shows the fungal hyphæ much more clearly than Lepra and frequently shows definite form and slight lobing, so that it is not so frequently taken for an alga.

A species of Tetraspora was collected at Grinnell and a form of Palmella at Fayette. *Rhaphidium polymorphum* Fresen. is common at both places and var. *aciculare* (A. Br.) Rabenh. has occurred at Grinnell, both forms being new to Iowa. Also another form found at Fayette was provisionally referred to *Rhaphidium convolutum* (Corda) Rabenh.

Of the Zygnemaceæ, the genera Spirogyra, Zygnema and Mougeotia were found, *Mougeotia genuflexa* (Dillw.) Ag. was collected at Fayette, and has not been previously reported from Iowa. The ten Spirogyras and two Zygnemas are reserved for further study.

Of the Nematogeneæ a number of genera and species have been found in the two places. *Isactis fluviatilis* (Rab.) Kirch., was once collected at Fayette on damp limestone, and a species of Rivularia was also collected there. The Isactis is new to the flora of Iowa, as is also *Scytonema myochrous* Ag., frequently found at Fayette on damp, shaded limestones. *Nostoc commune* Vauch., is common on wet soil in both localities, and *Nostoc muscorum* Ag., was frequent on mosses, and *Nostoc pruniforme* (Roth.) Ag., in ponds at Fayette, the last often reaching the size of a plum.

The last two species of Nostoc have not been previously reported from Iowa. *Cylindrospermum comatum* Wood occurs frequently at Grinnell, on wet soil along brooks. The plant has not been previously reported in Iowa. Another *Cylindrospermum* is found here, but the species has not been determined. *Lyngbya vulgaris* (Kuetz.) Kirch., and *Microcoleus terrestris repens* Kg., both occur on damp soil at Grinnell, and are new to the state. *Oscillaria tenerrima* Kuetz., and *Oscillaria princeps* Vauch., from Fayette, and *Oscillaria tenuis* Ag., from Grinnell, are new to the Iowa flora; and *Oscillaria limosa* Ag., was also collected at Fayette. *Phormidium tenue* (Menegh.) Gomont., is another alga frequently seen at Fayette and not previously reported from Iowa. Also *Beggiatoa alba* (Vauch.) Trev., occurs frequently at both places, and has not been reported for Iowa.

Merismopedia glauca (Ehrenb.) Naeg. occurs frequently at both places, and *Gloeocapsa magma* Kg. occurs frequently on granitic bowlders at Fayette, while *Gloeocapsa arenaria* (Hass.) Rabh. occurs abundantly in a greenhouse at Grinnell. Both of the Gloeocapsas are herein reported for the first time in Iowa. Another species of the genus occurs at Fayette with *Scytonema myochrous*, but this has not been determined.

The polymorphous *Chara fragilis* Desf. occurs frequently in small pools along the Volga river at Fayette, and has not been previously reported in Iowa so far as the writer can ascertain.

No doubt a considerable number of the plants reported herein for the first time have been collected and studied by other workers at various times, without publishing any record of the work done upon them. There is a most interesting and instructive field, for one who may have time and inclination, in the algæ of Iowa.

In closing the writer wishes to express his thanks to Miss Josephine E. Tilden for aid in the determination of a number of difficult species.

COHESION OF WATER AND OF ALCOHOL.

BY EDWIN MORRISON.

At the meeting of the Iowa Academy of Sciences in 1904 I read a paper descriptive of a new arrangement of a cohesion of water apparatus adapted to elementary laboratory work. The ease of manipulation, and close agreement of results in ordinary laboratory work led me to the thought of testing the accuracy of the standards of cohesion of water as ordinarily given in text-books and manuals. To my surprise, after a careful search through a number of the best text-books, manuals and works containing physical tables and constants, I found but one result tabulated, that of Gay-Lussac. There may be two reasons why the above author's data has been so universally accepted. First on account of the difficulties attending the use of the ordinary form of apparatus for finding the cohesion of a liquid. Second, the general feeling that the "Old Master Experimenters" left nothing undone or out of account in their experiments.

I need not here give a detailed description of the apparatus, as such a description appears in the 1904 proceedings of the Academy. In brief, the apparatus consists of a circular disk of glass cemented to the base of an accurately turned wooden cone, which has an eyelet screwed into the apex of the cone for suspension from one arm of a scale beam. The experiment consists in adding known weights to the scale pan opposite to the cone until the glass is separated from a vessel of water which is placed immediately under the disk—the disk having been previously pressed down until it was in contact with the water. If the disk when pulled away from the water is wet then we

know that a layer of water equal in area to that of the disk has been torn apart by the counterpoise weights. Knowing the area of the disk and the number of grams to separate it we can calculate the number of dynes per centimeter to separate the molecules of water.

Before giving the data and results of the experiment it may perhaps be well to state the precautions taken in the experiment. First, in order to insure that the water used was chemically pure, ordinary laboratory distilled water was redistilled in Jena glass vessels. All the ordinary tests failed to show traces of soluble salts in this water. Second, the disk was thoroughly cleansed by washing in a solution of potassium hydroxide; followed by washing in a solution of potassium dichromate and sulphuric acid; then in alcohol; then the disk was dried in a current of air and washed again in redistilled water. Third, a delicate laboratory scale with a rider weight was used in the experiment.

Data: -Diameter of the disk.

1 Measurement -106.62 m.m.
2 Measurement—106.98 m.m.
3 Measurement—107.27 m.m.
4 Measurement—106.94 m.m.
5 Measurement—106.54 m.m.
6 Measurement—106.74 m.m.
7 Measurement—107.20 m.m.

Average.. ....106.898 m.m.=10.6898 c.m.

Test No. 1: —The number of grams to separate the disk from water at 4°,C.

Trial 1:—48.725.
Trial 2:—48.730.
Trial 3:—48.725.
Trial 4:—48.733.

Average..48.728.

Test No. 2:—The number of grams to separate the disk from water at 7°,C.

Trial 1:—48.710.
Trial 2:—48.715.
Trial 3:—48.725.
Trial 4:—48.730.

Average..48.720.

Test No. 3:—The number of grams to separate the disk from water at 7°,C.

Trial 1:—48.630.
Trial 2:—48.640.
Trial 3:—48.655.
Trial 4:—48.675.

Average..48.650.

The diameter of the disk being 10.6898 c.m., the radius being 5.3449 c.m., the area is 89.7200 sq. c.m. In the first test given above it required 0.5431 g. to separate one square c.m. of water. In the second, 0.5430 g. and in the third, 0.5421 g. The average of the three tests is 0.5427 g. per square c.m. which is equal to 531.846 dynes per square c.m.

In the same way tests were made upon ninety-five per cent alcohol—specific density 0.8169. In five independent tests the following number of grams were required to separate the disk from the alcohol: 24.63, 24.64, 24.65, 24.65, 24.80; making an average of 24.674 grams. This makes 0.275 g. per square c.m. or 269.500 dynes per square c. m. In comparing these results with those of Gay-Lussac, we find that he used a disk which was 11.86 c.m. in diameter, and that it required 59.40 g. to separate the disk from water, and 31.08 g. to separate it from alcohol with specific density of 0.8196. This is 526.875 dynes per square c.m. for water, and 275.693 dynes for alcohol. By a careful observation of the above data it will be seen that, up to a certain limit, the cohesion increases upon standing. At present I see but two reasons for this. First, in case of solutions

in which a salt is dissolved, evaporation may increase the concentration and thus increase the cohesion. Second, in the use of water or any pure liquid certain substances may be dissolved from the air, thus increasing cohesion. Either of these two explanations leads to the suggestion that cohesion in a liquid is a function of the molecular weight of the dissolved substance, and that cohesion may be used to find the molecular weight of a dissolved substance in the same way as varying the freezing point, or the boiling point in the surface tension method. I have tested this in the case of sodium chloride dissolved in water, and find that with solutions containing a half gram molecule, a gram molecule, and a gram and a half molecule there is a constant ratio in the number of grams to separate the disk from the solution. Similar tests have been made with water solutions of urea and a constant ratio found.

Tests are also being made with naphthalin and urea dissolved in benzene. But these latter experiments could not be completed in time to embody them in this paper, except to show their indicated results. Neither could the constants for the different substances be computed like the constants used in the freezing point and the boiling point methods. Neither could these latter experiments be carried to a degree of completion to enable one to judge whether the method of cohesion will be a practical method for laboratory purposes. There will, perhaps, be two objections to it. First, on account of a considerable quantity of the liquid solution being required in a test, the expense will be greater than in the freezing point and the boiling point methods. Second, evaporation will change the degree of concentration of the solution in the case of volatile liquids. The advantages of the method are the inexpensiveness of the apparatus and the ease of manipulation.

PLATE VIII.

Method of cone suspension in apparatus for finding the cohesion of water.

THE SLIME MOULDS OF NEW MEXICO.

BY T. H. MACBRIDE.

No flora of the world has lately so much occupied the attention of botanists as that which they term xerophytic, the flora of the desert. This, for several reasons. In the first place, all deserts are now more easily accessible. The rush of commercial enterprise has at last penetrated every corner of the globe; even the deserts have been exploited and the way of the naturalist is made plain as never before. In the second place, this very circumstance makes possible now the study of desert-life as a whole, a thing hitherto impossible. True, in the days gone by, thanks to Parry, Pringle and others of the type, the flora of desert regions was not without representation more or less complete in the herbaria of the world, but even where most complete the several species were viewed as isolated specimens, strange enough no doubt; but no closet-student of such things had any idea of their profound meaning, of their wondrous association with each other in the land of their native habitat, of the significance of ten thousand minor adaptations which make a land and its flora kin, perfectly unintelligible and unmeaning unless seen together and in mass.

To one who thus attempts the flora of the North American deserts, a surprise will come, first perhaps in the profuse variety which marks a land of apparent inhospitable sameness. Every form of vegetable life that finds expression anywhere has a place, too, by some representative or other in the desert. There are trees, there are shrubs; there are vines, there are herbs; there are mosses

and ferns, fungi and slime moulds; so that one is quickly impressed with the thought that the flora of the desert is but a transformation, a replica, in miniature sometimes, of that with which we are all familiar in happier or, as we think, perchance, more normal fields.

It was, therefore, not without surprise that we found slime moulds in the desert. The filmy plasmic sheets and streams that creep in apparently aimless channels about our northern world would seem impossible in the hard conditions of the desert air where rains sometimes fail for months or even years together and even the dew is not infrequently forgotten.

The New Mexican and Arizona deserts are, however, very varied in just this particular. These deserts are generally all high, three or four thousand feet above the sea, and are by no means level; they offer plains and hills, they are broken by mesas and ridges and mountains, mountains where we have an altitude of ten or twelve thousand feet. These high points, for reasons that the meteorologist must explain, gather the scanty clouds. Here also stands a limited coniferous forest whose perennial foliage gathers the showers of summer and in winter sifts the snows and so holds on the tops of the mountains in wide scattered isolated groves, tufts of forest rising like islands over the far-spreading gray waste of the common Sahara.

Now it is on these mountain-tops that all the species here listed are collected. Here fallen trees afford the necessary amount of decaying organic matter for abundant food, and once wet either by the melting snows of spring or the showers of summer, hold for months together in their rotten bulk the moisture that makes possible plasmodic life. In other words, although in the midst of the desert, a desert extending for hundreds of miles in every direction, we have, nevertheless, here true forest conditions and all the children of the forest here find place; here are oases and these afford conditions suited to the phase of vegetal life with which we are all familiar.

The list of species that here follows exhibits, accordingly, many familiar types:

1. *Fuligo ovata* (Shaeff) Macbr. One specimen; very small.

2. *Physarum nefroideum* Rost. Common; but specimens all immature.

3. *Tilmadoche alba* (Bull.) Macbr. Common; typical.

4. *Tilmadoche viridis* (Bull.) Sacc. Common; typical.

5. *Leocarpus fragilis* (Dicks) R. Abundant; typical.

6. *Reticularia lycoperdon* Bull. Only one specimen; typical.

7. *Cribraria aurantiaca.* Immature; scarce.

8. *Dictydium cancellatum* (Batsch) Macbr. Rare; small.

9. *Lamproderma arcyrionema* Rost.. Rare; variable.

10. *Stemonitis maxima* Schw. Rare; the tufts short and small, but the spores typical.

11. *Stemonitis axifera* (Bull.) Macbr. Rare; a single tuft collected; the specimens typical except that the spores are nearly smooth. This may yet be *S. ferruginea* Ehrenburg.

12. *Stemonitis smithii* Macbr. Sporangia rather large; spores smooth and small as usual.

13. *Stemonitis webberi* Rex. The specimens here referred agree in many particulars with Rex's type but differ in the symmetry, beauty and uniformity of the capillitial meshes. These are not quite so large, but are fine, open and persistent. Some free tips appear rather more prominent than is usual in Stemonitis. The spores are minutely roughened; under the lens purplish or violaceous brown. The tufts are small, about eight or ten mm. high; the stipe short and hypothallus well developed. A New Mexican variety.

14. *Comatricha stemonitis* (Scop.) Sheld. Rare: typical; only one gathering.

15. *Lycogola epidendrum* (Bux.) L. One typical specimen so far collected.

16. *Arcyria nutans* (Bull.) Grev. Typical: not common.

17. *Arcyria incarnata* Pers. Typical, the colonies, however, very small and scattered.

18. *Lachnobolus occidentalis* Macbr.

19. *Hemitrichia stipitata* Massee. Typical; rare.

20. *Hemitrichia clavata* (Pers.) Rost. Rare. The common Mississippi valley form collected.

21 *Hemitrichia stipata* (Schw.) Rost. Typical and fine: collected abundantly on fallen Populus. In fine condition in the last week of August.

22. *Physarum flavicomum* Berk.

23. *Trichia decipiens* Pers. Typical, save that the spores are roughened and not reticulate as in the Mississippi valley. The spores correspond to those of European gatherings.

24. *Trichia persimilis* Karst. Not common.

25. *Perichaena corticalis* (Batsch) R. Typical on the inside of the bark of fallen trunks.

The Myxomycetes or slime moulds are of world-wide distribution. As we regard them, they are an ancient group which, notwithstanding extreme simplicity of structure, has broken into all sorts of species and forms. There are some four or five hundred of these curious organisms known, and it is safe to say that no other group of equal size could easily be selected in which the species are as a whole more definitely limited or defined. They are variable, it is true, but not more so than lichens or asters or oaks; the difficulty lies in the fact that their variations all lie on the stage of our microscopes and are recognizable only under the best lens that our factories may supply.

Notwithstanding this world-wide distribution it still appears that species have their individual range; not all, by any means, are cosmopolitan. The continents have their characteristic species, even genera as we now reckon them. There are forms in the Maine woods that have not yet been seen on our Iowa prairies nor in the forests of our valley; there are types in Oregon and Washington elsewhere unknown and many there which correspond to those of western Europe more closely than to those of the eastern

United States. Colorado and Southern California have characteristic species.

It is, therefore, with surprise that I present here a list of species in nearly all respects such as might be gathered in almost any grove in eastern Iowa.

This is the more remarkable when we discover that the phenogamous species of the locality in question are nearly all western or southwestern; scarcely one, unless, perchance, some introduced weeds or possibly some of the grasses or composites, is characteristic of the flora of the northwestern United States or of the upper Mississippi valley. We have *Pinus ponderosa*, *Pinus edulis*, *Pseudotsuga douglasii*, *Abies concolor;* we have southwestern or western oaks, junipers, barberries; among the trees, only the quaking asp is familiar to our northern eyes.

Now it must be further said that the quaking aspen, with its soft, rapidly decaying wood, affords here in Iowa a favorite habitat for many of our slime-mould species, and the same thing is true on desert mountain-tops. I found fallen trunks of Populus wet throughout, the rotten wood enclosed by the unbroken bark and supporting abundant and varied plasmodia. The fallen trunks of Pseudotsuga and Abies were also covered with traces of the minute organisms.

The conclusion to be drawn is perhaps this: the Myxomycetes being reproduced by minute spores are distributed by the prevailing currents of the air. During the season when the spores are exposed for distribution easterly and southeasterly winds prevail; in the winter, when northern and northwest winds obtain the species of Oregon and Washington are deep buried in snow. This might account for what we find on the assumption that the distribution is comparatively recent.

It seems to me, however, that we must take a wider view. The forests of the desert mountains are remnants: they are the survivors of a forest probably at one time continuous, possibly both east and west. Perhaps at one time the meteoric conditions that support the forests of the

northwest also obtained in New Mexico, and at that time the forms of slime-moulds common now in Oregon, were to be seen on the Sacramento Mountains. Probably at that time the species now found in Iowa ranged also farther west, as they do at present farther south. With the drying up of the desert, owing to causes that we are beginning to know and understand, the species of slime-moulds tolerant of the less humid climate, survived, and so where the climate of the mountain top resembles that of Iowa we have the same myxomycetan flora, although the phenogamous flora, under the same modifying agencies has followed different lines. The conditions for the higher plants are in any case different and the response has been different accordingly.

In conclusion, let me say that these most interesting organisms are easy of collection. They should be more abundantly brought in. August and September are the most likely months in which to obtain material suitable for study, although on the mountains of New Mexico good material may be sought in October and later. The fruiting follows the rains of August.

AN ECOLOGICAL STUDY OF THE SABINE AND NECHES VALLEYS, TEXAS.

BY JAMES E. GOW.

During the winter of 1902-3, and again during the winter of 1903-4, the writer was one of a party sent by the United States Bureau of Forestry to take stem analyses and valuation surveys on the holdings of the Kirby Lumber Company preparatory to making a working plan for the use of the company in the future treatment of its timber lands. The holdings of this company lie in Hardin, Orange, Newton, Jasper, Angelina, Sabine and San Augustine counties, and include the largest continuous area of virgin Longleaf pine existing in the United States at the present time. Incidentally to the work in hand, occasion was taken to make a few observations on the ecology of the region, and these observations will be presented in the present article.

From the coast of the Mexican Gulf as far north as Beaumont the country is practically treeless. It is a flat coastal plain, flooded in wet weather, and its only striking feature is its monotony. Only along the banks of the Neches river are a few scattered trees—Gums, and Magnolias, and Cypresses covered with festoons of gray Spanish moss—reminders of the flora which is to be met with on a larger scale further up the stream. The town of Beaumont marks the southern boundary of the pine woods. On the northern edge of the town is to be found young Loblolly and Shortleaf pine, and even a few seedlings of the Longleaf may occasionally be found. From Beaumont to Silsbee, in Hardin county, along the G. B. & K. C. railway, the greater part of the pine timber has been destroyed,

but on all the higher lands the culled trees that the lumbermen have left give a clew as to the original flora. Much of this line, however, runs through swampy country, and there the lumbermen have made but slight inroads.

Except for a strip of two or three miles in width along the Neches river, and for occasional scattered "bay-galls" or inland swamps, that part of Hardin county lying north of Silsbee is covered by an almost pure stand of Longleaf pine. In the western part of the county this gradually shades off into Loblolly and hardwood forests. The region immediately north of Silsbee is so flat as to give the impression of a perfectly level plain. So flat is it that a rise of five feet in a little brook so narrow that one can step across it, will cause it to overflow for many rods on either side. In the northern part of Hardin county the land begins to be slightly rolling, and by the time we get as far north as the middle of Jasper county, we find some inequalities that may fairly be dignified by the name of hills.

The topography of the northern half of Jasper county will illustrate how new the region is geologically. In a gently rolling plain the streams have cut deep, narrow gulleys, with almost vertical banks, ten, twenty or thirty feet in depth. Over an area extending northward from the town of Jasper as far as the limit of our survey, were found many fragments of petrified wood. It is usually to be seen in small pieces lying on the surface of the ground, but some logs of five feet in length were found in stream beds. Several species were noticed, but have not been identified.

The topography of Orange county corresponds in the main with that of the southern part of Hardin county, except that the river swamps occupy relatively a greater area. With the same exception the topography of Newton county corresponds with that of Jasper county. Except near the rivers, Sabine and San Augustine counties are very hilly. Here the yellow, sandy clay of the more southern counties gives place to the so-called "red soil." Scattered every-

where are large fragments of hæmatite, and of soft sandstone deeply colored with iron. The clay itself is of a dark red tint. Simultaneously with the change of soil is an improvement in the character of the people and in the appearance of their homes, which indicate the greater fertility of the red soil. At the same time the character of the forest changes, and the pure Longleaf is succeeded by "High Hammock" Shortleaf pine mixed with hardwoods, on all the higher land, and the typical hardwood types on the lowlands. The last body of pure Longleaf pine of any size is in the southern part of San Augustine county. The species is found in a scattered and usually more or less stunted condition throughout Shelby and Nacogdoches counties.

Ecologically considered, the vegetation of southeastern Texas may be divided into a number of types, as follows:

I. PINE FLATS.

To this type belongs most of the eastern half of Hardin county, much of Orange county and the southern half of Jasper and Newton counties. The leading species is the Longleaf pine, but a few Loblollies, Shortleafs, and hardwoods are occasionally present. The best Longleaf is grown on these low lands. In the typical Longleaf forest there is no underbrush of any description, and as the trees attain a height of a hundred to a hundred and thirty feet, and seldom branch under eighty or ninety feet the effect is very striking. Unfortunately the best of these magnificent forests have already been destroyed and, if the present demand for yellow pine lumber continues, they will soon disappear utterly.

The following species were found in the Pine Flats:

PINUS PALUSTRIS Mill. *Longleaf Pine.*

P. TÆDA Linn. *Loblolly Pine.* In old fields and clearings and on edge of Longleaf area where it adjoins the swamp type. Sometimes the Pine Flats and swamps are separated by a third, or intermediate type, containing Longleaf, Loblolly, and hardwoods. Loblolly occurs rarely in the typical Longleaf country.

P. ECHINATA Mill. *Shortleaf Pine.* Sometimes found in old clearings in drier portion of Pine Flats.

LIQUIDAMBAR STYRACIFLUA Linn. *Sweet Gum.* Along borders of streams and near edges of swamps.

MAGNOLIA FŒTIDA (L.) Sarg. Rare along streams.

M. GLAUCA Linn. *Sweet Bay.* Along streams and edges of swamps.

JUNIPERUS COMMUNIS Linn. *Red Cedar.* Not uncommon in deserted clearings.

ACER NEGUNDO Linn. *Box Elder.* Banks of streams. Rare.

MORELLA CERIFERA (L.) Small. *Wax Myrtle.* Common.

RANUNCULUS TENER Mohr. *Buttercup.* Not uncommon.

VIOLA LANCEOLATA Linn. *White Violet.* Not uncommon.

VIOLA LANGLOISII Greene. *Violet.* Common.

CASSIA CHAMÆCRISTA Linn. *Partridge Pea.* Not uncommon.

SISYRINCHIUM GRAMINOIDES Bicknell. *Blue-eyed Grass.* Not uncommon.

S. MINUS Engelm. & Gray. Not common.

XANTHIUM SPINOSUM Linn. *Cocklebur.* Common in cotton fields and on roadsides,

ASTER TEXANUS Burgess. *Aster.*

A. PURPURATUS Nees.

SASSAFRAS SASSAFRAS (L.) Karst. Along streams.

MALUS SOULAIDI (Bailey.) Britton. *Crab.* In open places in pine woods, where it forms thickets.

ELIONURUS TRIPSACOIDES H. & B. Common.

II. PINE UPLAND.

The flora of this type is so nearly the same as that of the Pine Flats that a separate list is unnecessary. In addition to the foregoing, the following species occur on the high pine land of northern Jasper and Newton counties, Tyler county and Angelina county.

QUERCUS MINOR (Marsh) Sargent. *Post Oak.* Common; increasing northward.

Q. MARYLANDICA Muench. *Black Jack.* Not uncommon.

III. "HIGH HAMMOCK."

This is a local name applied to a very well marked type, and adopted by the Bureau of Forestry as a technical term applicable to that type. In the northern end of Jasper county, and the southern end of San Augustine, as the Longleaf pine begins to thin out, its place, on the higher land, is taken by a mixture of Shortleaf and hardwoods, with occasionally some Loblolly. In appearance the "High Hammock" differs totally from the Pine Upland. It is usually characterized by dense thickets of Shortleaf seedlings, often badly stunted by the shade of the hardwoods under which they grow. The Shortleaf is the typical species, but the following are found in considerable abundance:

NYSSA SYLVATICA Marsh. *Black Gum.* Near streams.

HICORIA ALBA (L.) Britton. *Hickory.*

HICORIA PECAN (Marsh) Britton. *Pecan.*

FRAXINUS AMERICANA L. *White Ash.*

QUERCUS DIGITATA (Marsh) Sudw. *Spanish Oak.*

Q. VELUTINA Lam. *Black Oak.*

Q. MINOR and Q. MARYLANDICA here become very common, but do not attain their maximum size.

Of trees common to Pine Upland and High Hammock are the Sassafras, Sweet Gum, Sweet Bay and Crab.

IV. SWAMP.

On either side of the Sabine, Neches and Angelina rivers, and extending back from one to six miles are dense Cypress swamps. Usually, the line dividing the swamp area from the Pine Flats, or Pine Upland, is extremely well marked. The dense underbrush of the swamp does not gradually thin out, as we approach the upland, the soil does not become noticeably dryer, nor do we see any scattered pines to indicate that we are approaching the Longleaf country. At a single step we pass from mud to grassy ground, from dense brush to much less obstructed view, from a forest of deciduous trees to a forest of conifers. In rare instances there is a shading off from one to the other, and an intermediate type of forest is formed, containing deciduous trees, Longleaf and Loblolly. For the most part the only conifers found within the swamp limits are Cypress and Loblolly.

During most of the year the swamps are overflowed and water stands in them to a depth of from a few inches to four or five feet. They are traversed by many small streams, and broken by some open bayous into which the water of the river backs during flood time.

V. LOW HAMMOCK.

The swamps are broken by low ridges of dry land varying in width from a few rods to half or three quarters of a mile. These ridges are known locally as 'Low Hammock." They bear a type of forest peculiar to themselves, but have many species in common with the surrounding swamp.

VI. HARDWOOD BOTTOM.

Along portions of the Sabine, the Neches, and the Angelina (more especially the latter) the swamp gives place to broad stretches of flat, dry land of slightly higher elevation. This is described as "Hardwood Bottom," because of the prevalence upon it of deciduous-leaved trees, or "hardwood." Frequently a broad Hardwood Bottom is found

next the river. Back of this comes a stretch of swamp, broken by occasional Low Hammock, and beyond this, in turn, lies the pine country. The difference between the Hardwood Bottom and Low Hammock is physical only. Their flora is identical.

TYPICAL TREES OF SWAMP, LOW HAMMOCK, AND HARDWOOD BOTTOM.

TAXODIUM DISTICHUM (Linn.) Rich. *Cypress.* Swamp. Abundant.

PINUS TÆDA Linn. *Loblolly Pine.* Frequent on border of swamp near Longleaf pine area, and on Low Hammock.

P. ECHINATA Mill. *Shortleaf Pine.* Occasional in same surroundings as foregoing species.

PINUS PALUSTRIS Mill. *Longleaf Pine.* Very rare in Low Hammock or Hardwood Bottom. Never in swamps.

HICORIA AQUATICA (Michx.) Britton. *Water Hickory.* Hardwood Bottom. Common.

HICORIA OVATA (Mill.) Britton. *Shagbark.* Hardwood Bottom. Common.

HICORIA GLABRA (Mill.) Britton. *Pignut.* Bottoms. Common.

HICORIA ALBA (L.) Britton. *Mocker Nut.* Bottoms. Common.

OSTRYA VIRGINIANA (Mill.) Koch. *Ironwood.* Bottoms Not very common.

FAGUS ATROPUNICEA (Marsh.) Sudw. *Beech.* Bottoms. Very common.

BETULA NIGRA Linn. *River Birch.* Bottoms. Uncommon.

QUERCUS ALBA Linn. *White Oak.* Bottoms. Common.

Q. LYRATA Walt. *Overcup Oak.* Bottoms. Rare.

Q. MICHAUXII Nutt. *Cow Oak.* Bottoms. Common.

Q. DIGITATA (Marsh.) Sudw. Bottoms and uplands. Edge of pine area. Common.

Q. NIGRA Linn. *Water Oak.* Swamps and bottoms. Abundant.

Q. LAURIFOLIA Michx. *Laurel Oak.* Not uncommon in Sabine river bottoms.

Q. BREVIFOLIA (Lam.) Sargent. Bottoms. Rare.

MAGNOLIA FŒTIDA (Linn.) Sargent. *Bull Bay.* Swamps and bottoms. Common.

M. GLAUCA Linn. *Sweet Bay.* Bottoms. Very common.

SASSAFRAS SASSAFRAS (Linn.) Karst. *Sassafras.* Bottoms. Rare

LIQUIDAMBAR STYRACIFLUA Linn. *Sweet Gum.* Swamps and bottoms. Very common.

CERCIS CANADENSIS Linn. *Redbud.* Clearings in hardwood bottom lands.

XANTHOXYLUM CLAVA-HERCULIS Linn. *Prickly Ash.* Bottoms. Common.

ILEX OPACA Ait. *Holly.* Bottoms. Very common.

CORNUS FLORIDA Linn. *Dogwood.* Bottoms. Rare.

NYSSA SYLVATICA Marsh. *Black Gum.* Swamps and bottoms. Very common.

NYSSA AQUATICA Linn. *Tupelo Gum.* Swamps only. Very common. Noticeable for the very marked taper of its trunk in the first ten feet. This peculiarity distinguishes all the species growing in the swamps, but is especially noticeable in the Tupelo.

FRAXINUS AMERICANA Linn. *White Ash.* Bottoms. Not common.

FRAXINUS LANCEOLATA Borkh. *Green Ash.* Bottoms. Not common.

F. CAROLINIANA Mill. *Water Ash.* Swamps. Common.

ULMUS ALATA Michx. *Wing Elm.* Swamps. Rare.

CELTIS OCCIDENTALIS Linn. *Hackberry.* Bottoms. Not common.

SAMBUCUS CANADENSIS Linn. *Elderberry.* Bottoms. Not common.

SMILAX RENIFOLIA Small. *Greenbriar.* Swamps. Very common, in places forming thickets that are absolutely impenetrable.

RUBUS CUNEIFOLIUS Pursh. *Blackberry.* Forms dense, often impenetrable, thickets in bottoms. Common also in old clearings.

R. NIGROBACCUS Bailey. *Blackberry.* Common in bottoms and all clearings.

ARUNDINARIA MACROSPERMA Michx. *Cane Reed.* Abundant in a few localities. Dense cane brakes occur at remote intervals in the bottom lands of the Sabine and Neches rivers and a few of their smaller tributaries.

ALNUS RUGOSA (Du Roi) K. Koch. *Alder.* Very common in swamps, forming dense thickets.

In probably few regions are the types of vegetation more sharply contrasted than in the Texan forests, a slight account of which I have here attempted to give. The ecology of this region merits a more thorough study than it was, in the nature of things, possible to give it in connection with the forestry survey. Such a study may, it is hoped, prove possible at some future time.

PLATE IX.

FIG. 1. Bottom land along Angelina river. Angelina county, Texas.

FIG. 2. View on bottom land along Angelina river. Angelina county, Texas

FIG. 1. Cut-over pine land. A view of what all the pine country is rapidly coming to.

FIG. 2. Louisiana Cypress swamp, near Red river, in very low water; showing great taper of Cypress and Tupelos.

PLATE XI.

FIG. 1. Virgin Longleaf Pine. Jasper county, Texas.

FIG. 2. Cypress swamp. Jasper county, Texas.

J. J. THOMSON'S THEORY OF MATTER.

BY L. BEGEMAN.

J. J. Thomson's theory of matter is largely the outgrowth of his own experimental researches in the nature and structure of electricity. In reading the records of his work it is often hard to discriminate in just what sense he uses the term "electricity." It is certainly not well defined whether the term stands for primordial energy or matter.

In only one instance does he speak with any definiteness on the point. He says, "that one view of the constitution of matter is that the atoms of the various elements are collections of positive and negative charges held together mainly by their electric attractions." Continuing at another point, he says: "All mass is mass of the ether, all momentum, momentum of the ether,and all kinetic energy, kinetic energy of the ether."

These statements would lead us to think that to him the term "electricity" and "ether" are at least synonymous. If there is any difference, it may be stated by saying that electricity is ether under a corpuscular stress. The term "corpuscular" here will explain itself later.

Electricity, we are told, has an atomic structure. The term "atomic" is used here in a general sense signifying merely that electricity is an aggregation of individual units of ether called corpuscles. As evidence of this divisibility of the electric charge, he first turns to the phenomenon of electrolysis. We know that when electricity is transmitted through a solution, the amount of the positive and negative charges is directly proportional to the number of ions

coming up to the electrode. A divalent element carries twice as much as a univalent; a trivalent three times as much. Electrolysis tells us, accordingly, that the magnitude of electrical charges on ionized atoms in solution is always an integral multiple of that on the hydrogen atom. As Helmholtz says, "if we accept the hypothesis that elementary substances are composed of atoms, we can not avoid the conclusion that electricity, positive as well as negative, is divided into definite elementary particles which behave like atoms of electricity."

The fact of the ultimate divisibility of an electric charge is more clearly grasped from the behavior of an ionized gas. When a gas is subjected to the influence of Roentgen rays it takes on conductivity. This conductivity is due to the presence of minute particles of electricity mixed with the gas. These particles can be filtered out of the gas through a plug of cotton wool. They can also be attracted or repelled out by the action of a strong electric field. The mass of these particles of electricity was determined by J. J. Thomson and other experimenters in various ways. It would take too long to discuss any of these methods in detail. The principal method, however, consisted in making the particles nuclei of visible vapor particles. In this manner, a cloud was formed and from the rapidity of motion of the descending cloud, under the action of gravity, the number of particles in a given charge was quite accurately determined. Knowing the number, the mass of a particle of electricity was easily obtained. The magnitude of this mass was found to be about $\frac{1}{1000}$ of the mass of a hydrogen atom. No matter what the nature of the ionized gas, it was always found that the mass of the particle was unvaried and that the charge it carried was negative in sign.

These negatively electrified particles denoted by J. J. Thomson as corpuscles are accepted by him as the primordial units of all matter. We recognize also that these corpuscles consist of ether under a very intense stress. The ether in the corpuscle is so much concentrated

that its density is greater than that of any known molecular mass. Furthermore, this corpuscle is in a sense dual in structure, consisting of an elongated mass of ether whose strain at one end constitutes the negative charge, while that at the other end constitutes an equal and opposite positive charge. It is deduced from the mathematical discussion, however, that the ether is so concentrated in the negative charge that it constitutes essentially the entire mass of the corpuscle.

Having considered briefly the nature of the corpuscle, let us consider for a moment the evolution of atomic matter from primordial conditions.

In the beginning, space was filled with a continuous medium called ether consisting in the aggregate of these primordial dual units called corpuscles. The corpuscular temperature was very high. In other words, the corpuscles were in a high state of motion which prevented any combinations at first. It is demonstrated, however, mathematically that such a tube of ether as the corpuscle by virtue of its motion in ether would gradually lose its kinetic energy through the process of radiation. In other words, a tube of ether moving in ether produces waves, the energy of which comes from the corpuscle. Accordingly, some corpuscles might lose their energy faster than others and would be first to come together to form those complex aggregations denoted by chemists as atoms.

An atom as presented us by Professor Thomson consists of a group of negatively charged corpuscles enclosed in a sphere of positive electrification. The nature of the atom is determined by the number and arrangement of the corpuscles inside this sphere of positive electrification. The corpuscles thus restrained are in rapid motion. In other words, the atom possesses corpuscular temperature. If the motions of the corpuscles are such as to be confined to the space inside the positive sphere, the atom is stable and in a neutral condition electrically. This means that the combined negative charges of the enclosed corpuscles exactly equals in quantity the charge on the surrounding positive sphere.

The theory assumes that the stabilities of different atoms are unlike. Under the action of a strong extraneous electric field, or by collision, or by the forces of solution, an atom may be sufficiently unstable as to lose one or more of its corpuscles. When this happens, it becomes electro-positive to the extent of the excess charge on the surrounding positively charged sphere. On the other hand, other atoms may possess such great stability, or low corpuscular temperature, that under similar conditions they are able to take in one or more additional corpuscles thus making them electro-negative to the extent of the charges of the excess corpuscles taken in. We thus have a division of atoms in kind; electro-positive and electro-negative. Hydrogen is an example of the first and chlorine of the second.

The valency of an atom is accounted for in a similar manner. When an atom is of such a nature that under natural conditions, it never loses more than one corpuscle, it is univalent and electro-positive; when it can lose two, it is divalent; when three, trivalent. On the other hand, atoms that can receive an additional atom and only one, are univalent and electro-negative. Those that receive two are divalent; three, trivalent. It is easy to see that the mutability of the atom within the range here indicated would be probable inasmuch as the simplest or least complex atoms, such as hydrogen, carry about one thousand corpuscles. It is clear also that the bonds ascribed to atoms by the chemist are merely the attractions of the excess charges on the atoms. All chemical affinity is electric attraction.

The Periodic Law of Mendelejeff is accounted for by the different arrangements of the corpuscles in the atoms. To illustrate this, Professor Thomson employs an experiment first made by Professor Mayer. In this experiment a number of magnets are made out of a piece of steel knitting needle. These magnets are thrust through pieces of cork so that they float in perpendicular positions with the positive poles up. Such floating magnets, of course, will repel each other. If a powerful negative pole of a bar magnet is

held above them, they will all be attracted by it and will arrange themselves in some definite geometrical configuration. Three floating magnets will give a triangle. Five magnets arrange themselves either as pentagon or as a quadrilateral with one magnet at the goemetrical center. As the number of floating magnets is increased, the figures will successively vary. Large numbers of magnets give combinations of the elementary figures. For instance, with three, we have a triangle; with eleven, a triangle inside of an octogon; with thirty-five, the triangle appears again surrounded by more complex figures. Accordingly, it is argued by analogy that the negative corpuscles inside of the sphere of positive electrification arrange themselves in definite configurations which determine the similarities and differences in atoms. Any two atoms may differ greatly in weight which means that they differ greatly in the number of corpuscles they contain; yet if they should possess in common some elementary corpuscular configuration, they would exhibit some similarity in properties as is the case with lithium and sodium.

It is impossible to do justice to this interesting theory in a brief discussion since its speculations are based largely on mathematical deductions. It might be interesting to note in what manner it lends itself to the explanation of some of the undetermined phenomena of nature.

An example where free corpuscles are produced under the action of a strong electric field is seen in the Crooke's tube. The so-called cathode rays are streams of negatively charged corpuscles expelled from the atoms of the residual gas in the tube. These corpuscles, as we should expect, are always of the same kind, no matter what the nature of the residual gas. We are also aware that other rays quite different from the cathode rays emanate from the anode of a Crooke's tube. Those from the anode consist of streams of atoms of the residual gas positively charged. We would expect the existence of such ionized atoms from the theory since it is evident that the forcing out of negative corpuscles would leave the atom with an excess charge of positive electrification.

The X-rays which emanate from a Crooke's tube are assumed to be ether waves produced by the rapid motion and intense collisions of the corpuscles.

Radium, in the light of this theory, consists of atoms in a state of instability. Radium atoms are probably in a period of transition. Radium gives off B-rays, which like the cathode rays of a Crooke's tube consist of negatively charged corpuscles. These corpuscles being ejected from the radium atom leave behind an excess charge of positive electrification. The positively charged atoms interact on each other and give place to X-rays like those emanating from the anode of a Crooke's tube. Finally, by virtue of the B-rays, Y-rays are also produced. The Y-rays are identical with the X-rays of a Crooke's tube.

Again, we infer from this theory that mass formation from primordial conditions is the result of a spontaneous and prolonged process of accretion. First corpuscles, then atoms of varied structure; finally, atoms by their electric attractions produced the molecules that make up the aggregate masses.

In the summer time, it is customary to say that the high relative humidity of air prevents the retention of static charges on insulated conductors. The more probable reason, in the light of modern research, is that the air is given conductivity by the presence of a large number of free corpuscles due to the radio-active gases of damp soils.

Finally, we note the interesting fact that a substance might have a very high corpuscular temperature and yet a very low atomic or molecular temperature. In other words, the expression "corpuscular temperature" does not mean heat in the accepted sense. It means kinetic energy of corpuscles which results in continuous ether wave radiation of different periods.

It is possible then for a nebulous mass in the heavens to give off an intense light and yet be very cold. The light of a comet increases in intensity as it approaches the sun, not because of the increased temperature of its substance, but rather because of an increased corpuscular activity induced by some manner by the sun.

VARIATION IN RAY FLOWERS OF ANTHEMIS COTULA AND OTHER COMPOSITES.

BY H. S. FAWCETT.

The object of this study was to determine the amount of variation occurring in the number of ray flowers of the Mayweed (*Anthemis cotula* L.), to compare the variations occurring in different localities, and also the variations in different plants of the same locality, and finally to compare this variation with that of a few other species of Compositæ.

For this study of Anthemis the plants of each locality were picked indiscriminately within a radius of perhaps 100 feet. The count of the available heads of each plant was kept separately for comparison, as shown in the appended tables.

The counting of the ray flowers was done very carefully, and in order to avoid possible error, those heads injured by insects or other causes were discarded. One thousand three hundred and ninety-four heads of Mayweed were counted from seven different localities; four localities in Iowa, two, four and forty-five miles apart, and three localities in Washington state, Seattle, Bellingham, and Hot Springs.

It will be seen by the tables that the predominating number of ray flowers in each locality was thirteen, with the exception of Seattle, where the number counted was not sufficient to give any evidence of a real difference. Tables and curves are shown for the entire number of heads counted, and also for those of each locality. It will be noticed that all these curves for the Mayweed are much steeper on the side below thirteen ray flowers, than above

this number. This suggests the question, whether or not this indicates a shifting of the species from a lower to a higher number of ray flowers. It was also noticed that the plants of Anthemis growing in rich soil near barns had heads of greater variability in the number of ray flowers, than those in poorer soil; showing the theory to be true in this case, that more food causes greater variability.

The ray flowers of 1,160 heads of Yarrow (*Achillea millefolium* L.) were next counted, in four different localities, three localities in the Bitter Root mountains of western Montana about fifteen miles apart, and one at Ames, Iowa, just south of the College campus. In Achillea, heads containing five ray flowers greatly predominated, the entire variation being from two to seven. With one slight exception it will be noticed that the curves are steeper on the side above five than below that number. The curves for the three localities of the Bitter Root mountains are very similar in form and amount of variation. The ray flowers of these localities were much larger and purer white in color than those of Iowa.

In addition to the Mayweed and Yarrow, heads of three other species in the Bitter Root mountains were counted; *Senecio triangularis* Hook, *Aster adscendens* Lindl., and *Erigeron salsuginosus* Gray. In the curves for *Aster adscendens* it will be noticed that in nearly every case the line falls for odd numbers of ray flowers and rises again for even numbers. In this plant, as also in *Erigeron salsuginosus*, there seems to be no predominating number of rays as in Anthemis and Achillea.

The time element has not been taken into consideration in this study except in the case of Anthemis for Ames, where tables and curves are compared as between August and September. This time element according to Schull (1904) is a very important factor in variation. He says, in speaking of Asters, "There is a continuous and more or less regular change in the variable characters from day to day throughout the season."

The mean magnitude, the index of variability, and coefficient of variability, with probable error, has been worked out very carefully for each species and each locality with the exception of Erigeron, for which these would have been of little value.

The following formulæ have been used in working out the mean, the index of variability, the coefficient of variability, and the probable error.

$$A = \frac{E\,(V.\,f)}{n} \text{ where } A = \text{the } \textit{mean;}$$

V = the frequency of a class, and n = the total number of variates.

$$O = \sqrt{\frac{E(x^2\ f)}{n}}\,\mathfrak{C} \text{ where } O = \text{the index of variability}$$

(standard deviation), x=the deviation of a class magnitude from the mean, and $\mathfrak{C}$ = the difference between the upper and lower limits of a class, which is unity in this case.

$$C = \frac{O}{A} \text{ where } C = \text{the coefficient of variability.}$$

$$E_A = .6745\frac{O}{\sqrt{n}},\text{ and } E_O = 6745\frac{O}{\sqrt{2n}} \text{ where } E_A \text{ and } E_O$$

denote the probable error of mean and probable error index of variability respectively.

The subject of the variation of ray flowers in the Compositæ has been studied by a number of investigators in recent years. G. H. Shull (1902) studied the variation in the bracts, rays and disk florets of a number of species of Asters. W. S. Tower (1902) studied the variation of ray flowers of *Chrysanthemum leucanthemum*. Shull in the

June Bot. Gaz. for 1904 has a very complete paper on plane constants for *Aster prenanthoides*.

The work for this paper was done in the summer and fall of 1904 under the direction of Prof. L. H. Pammel of the Iowa State College, Ames, from whom valuable suggestions were obtained. Acknowledgment must also be made of important suggestions from Prof. H. E. Summers of the same place, who first suggested the study of Anthemis. Valuable aid was rendered by Charlotte M. King, in constructing the tables and curves, and by Estelle D. Fogel in the mathematical work of the paper.

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PLATE XII.

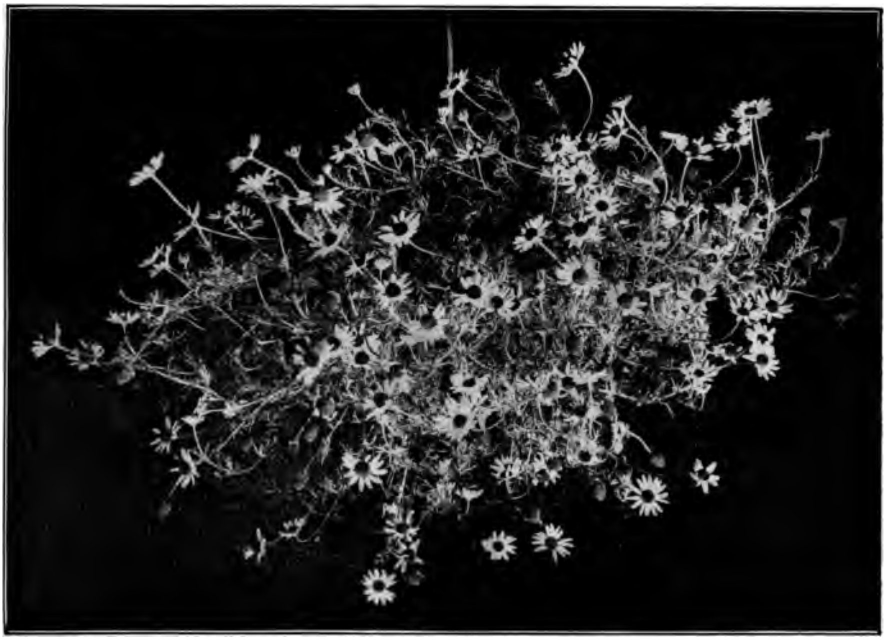


PLATE XIV.

Plants.	Mean.	Index of variability.	Coefficient of variability.
emis Cotula	13.6515 ± .03063	1.6950 ± .02166	.1241
llea Millefolium	4.7903 ± .01214	.6142 ± .00858	.1282
ecio triangularis	6.6606 ± .05901	1.2386 ± .04173	.1859
: adscendens	27.6428 ± .1936.	5.0381 ± .1401	.1818

Number of rays per head.

		2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	Total.
emis Cotula	No. of heads							1	2	9	42	160	649	247	125	55	37	30	16	13	4		.	1392
llea Millefolium		1	33	261	785	82	2																	1164
ecio triangularis			6	13	45	95	136	127	5	2	1	2	2											434
- adscendens																1	2	1	4	15	9	19	19	------
ron salsuginosus																				1	2	0	4	-----
	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	
adscendens (cont.)	23	21	25	18	25	11	25	19	19	16	10	1	4	6	10	3	1	1						308
ron salsuginosus (cont.)	1	3	8	6	19	00	5	14	3	12	10	11	11	12	7	7	8	9	5	5	2	00	2	174

FIG. 1. Condensed table for all species studied.

Anthemis Cotula

lities		No. of rays 8	9	10	11	12	13	14	15	16	17	18	19	20	21	Total	a	σ	C
Ia south of e August	No. of heads			1	1	2	76	39	12	12	10	12	6	3		174	14.4310±.1008	1.972±.0713	.1366
Ia. south of e 9/23/04				1	12	39	179	59	27	19	14	5	5	4	2	361	13.7174±.0619	1.7465±.0438	.1272
s north of s				2	9	50	150	25	14	2						252	12.9405±.0381	.8955±.0269	.0692
s north of s				2	5	18	69	37	31	15	10	11	5	6	2	211	14.388 ±.1018	2.157 ±.0708	.1422
and Iowa les from Ames			1		6	30	76	21	11	5	3	2	2			157	13.2930±.0788	1.4649 ±.0557	.1102
hrings Wash a/04		1	1	1	2	3	9	4	1							22	12.4090±.2400	1.6694 ±.1697	.1344
gham Wash. /'04				2	7	9	76	42	15	2						153	13.3202±.0556	1.0204 ±.0393	.0766
lle Wash. 9/'04						9	19	20	14	2						64	13.7031±.0906	1.0559±.0640	.0770

FIG. 2. Shows variation in *Anthemis cotula* for different localities.

PLATE XIII.

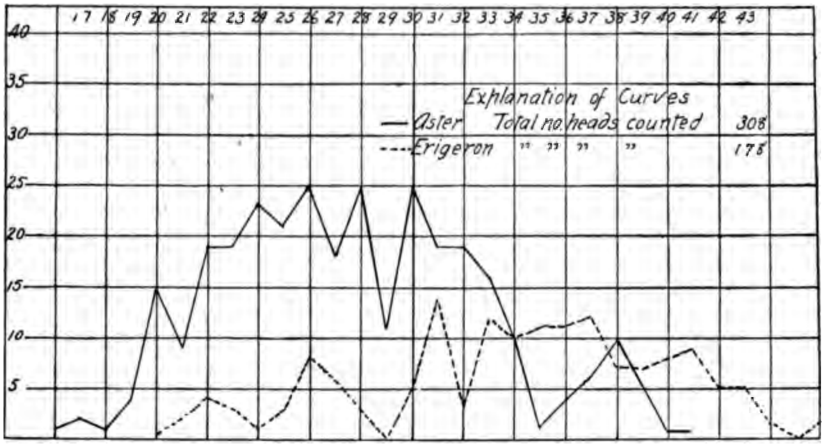


FIG. 1. Figures at the top indicate number of ray flowers per head, figures at the left the number of heads in each class.

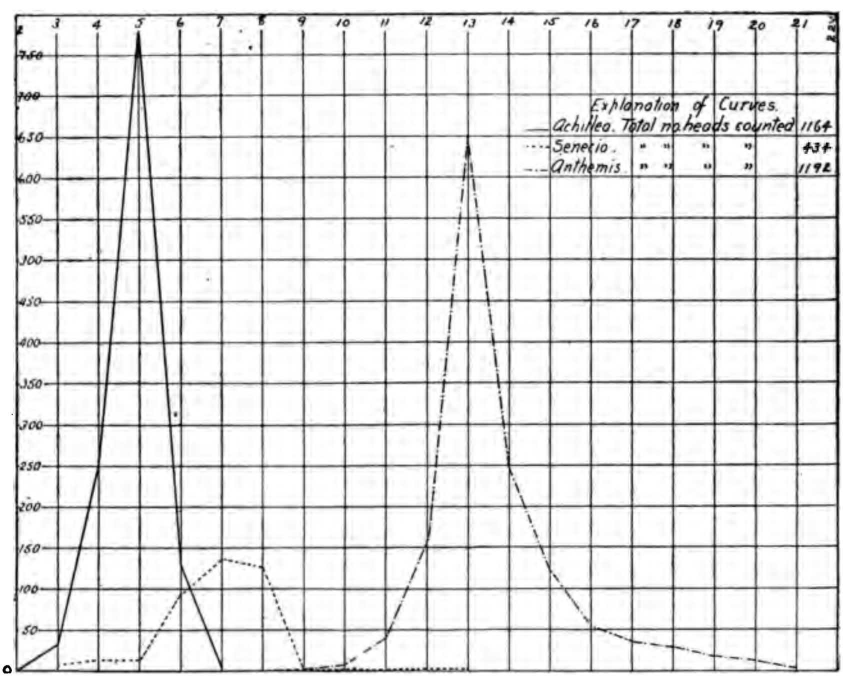


FIG. 2. Figures at the top indicate number of ray flowers per head, figures at the left the number of heads in each class.

Plate XIV.

Plants.	Mean.	Index of variability.	Coefficient of variability.
Anthemis Cotula	13.6515 ± .03063	1.6950 ± .02166	.1241
Achillea Millefolium	4.7903 ± .01214	.6142 ± .00858	.1282
Senecio triangularis	6.6606 ± .05901	1.2386 ± .04173	.1859
Aster adscendens	27.6428 ± .1936.	5.0381 ± .1401	.1818

Number of rays per head.

		2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	Total.
Anthemis Cotula	No. of heads							1	2	9	42	160	649	247	125	55	37	30	16	13	4		.	1392
Achillea Millefolium		1	33	261	785	82	2																	1164
Senecio triangularis			6	13	45	95	136	127	5	2	1	2	2											434
Aster adscendens																1	2	1	4	15	9	19	19	-----
Erigeron salsuginosus																				1	2	0	4	-----

	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	Total.
Aster adscendens (cont.)	23	21	25	18	25	11	25	19	19	16	10	1	4	6	10	3	1	1						308
Erigeron salsuginosus (cont.)	1	3	8	6	19	00	5	14	3	12	10	11	11	12	7	7	8	9	5	5	2	00	2	174

Fig. 1. Condensed table for all species studied.

Anthemis Cotula

Localities		8	9	10	11	12	13	14	15	16	17	18	19	20	21	Total	a	σ	C
				No. of rays.															
Ames Ia south of College August	No. of heads.			1	1	2	76	39	12	12	10	12	6	3		174	14.4310±.1008	1.972±.0713	.1366
Ames Ia. south of College 9/23/04				1	12	39	174	59	27	19	14	5	5	4	2	361	13.7174±.0619	1.7465±.0438	.1272
2 miles north of Ames				2	9	50	150	25	14	2						252	12.9405±.0381	.8955±.0269	.0692
6 miles north of Ames				2	5	18	69	37	31	15	10	11	5	6	2	211	14.388 ±.1018	2.157 ±.0708	.1422
Le Grand Iowa 45 miles from Ames			1		6	30	76	21	11	5	3	2	2			157	13.2930±.0788	1.4619 ±.0557	.1102
Hot Springs Wash 9/4/04		1	1	1	2	3	9	4	1							22	12.4090±.2400	1.6694 ±.1697	.1344
Bellingham Wash. 9/6/'04				2	7	9	76	42	15	2						153	13.3202±.0556	1.0204 ±.0393	.0766
Seattle Wash. 9/9/'04						9	19	20	14	2						64	13.7031±.0906	1.0559 ± .0640	.0770

Fig. 2. Shows variation in *Anthemis cotula* for different localities.

PLATE XV.

Plant	10	11	12	13	14	15	16	17	18	19	20	21	Total no. of heads on each plant.
No. 1	1	3	9	14	2								29
2		1	3	6	1								11
3		1	3	10									14
4		2	1	18									21
5		1	1	18	4	1							25
6		3	5	10	8	7		1					34
7		1	3	12	6	1	2						35
8			1	8	2								11
9			2	4	2								8
10			2	17									19
11			2	19	3								24
12			1	2	3	1							7
13			1	7	6	3							17
14			3	12	5		1						21
15			2	2	4	6	12	11	5	4	4	2	52
16				5									5
17				8									8
18				1	6	5	1						13
19				1	2	3	3	3		1			13
Total no. of heads in each class.	1	12	39	174	59	27	19	14	5	5	4	2	361 Sum

No. of rays

Plant	10	11	12	13	14	15	16	17	18	19	20	No. of heads on each plant.
No. 1	1		2	4	3	2	4	2	2	2	1	23
2		1		3	8		4	4	5			25
3				4								4
4				6								6
5				9								9
6				2	1							3
7				10	2							12
8				6	5	3						14
9				7	4	1						12
10				7	9	1						17
11				18	7	3						28
12						2	3	1	4			10
13							1	3	1	4	2	11
No. of heads in each class.	1	1	2	76	39	12	12	10	12	6	3	174 Sum

No of rays.

FIG. 1. Figures at the top indicate number of rays, those at the left the number of heads, showing individual variation of

Plant	No. of rays. 10	11	12	13	14	15	16	17	18	19	20	21	Total no. heads on each plant
No 1	2	4	11	13									30
2		1		5	5	6	7	2	5	2	1		35
3			2	11	5	1							19
4			4	7	2	1			1	1			16
5				2	2	2							6
6				2		4		1					7
7				2	4	3							9
8				2	5	4	1						12
9				3	1	5	1	2	1				13
10				3				2	3	1	4	2	15
11				4	1		1						6
12				15	11	2	1						29
13					1	2	1	1					5
14						1	3	2	1	1	1		9
Total no heads in each class	2	5	18	69	37	31	15	10	11	5	6	2	Sum 211

FIG. 1. *Anthemis cotula*, six miles north of Ames, showing individual variation.

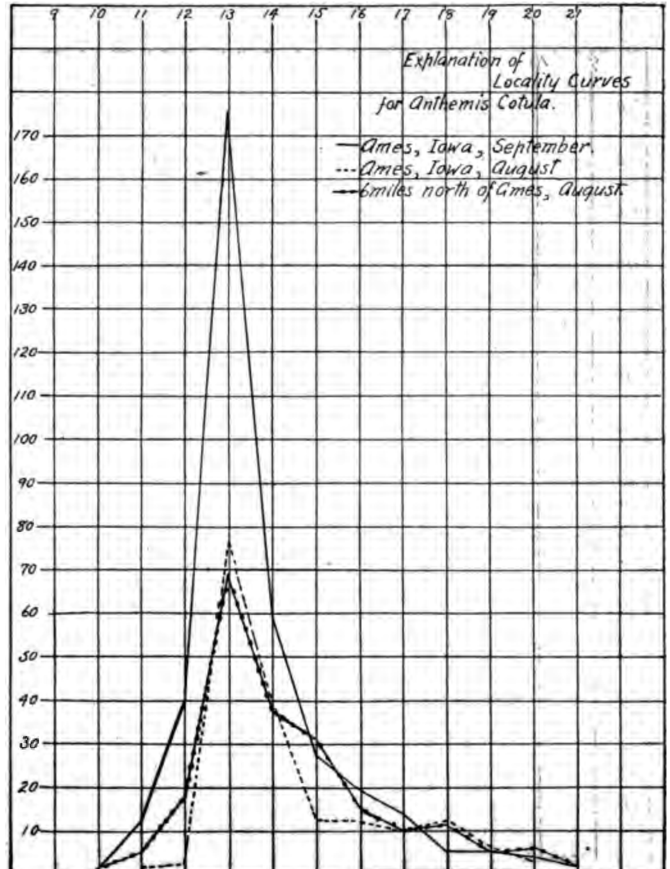
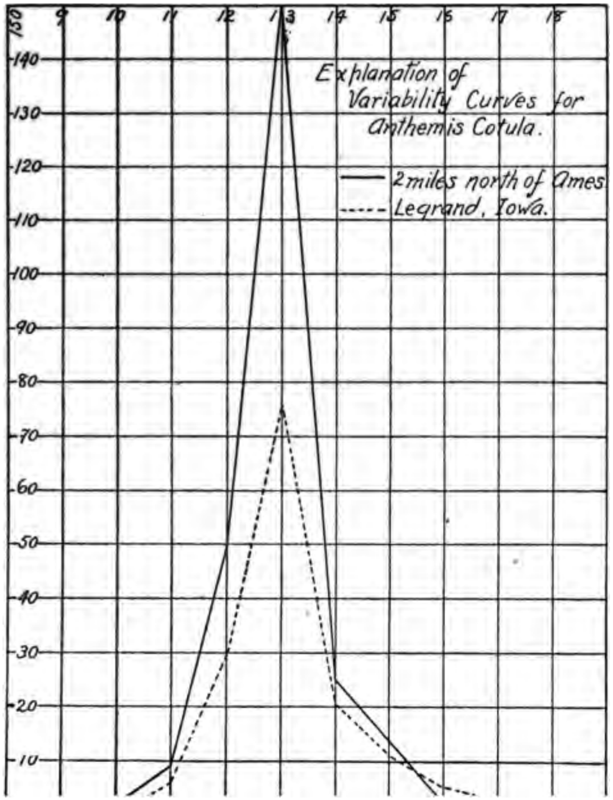


FIG. 2. Locality curves for *Anthemis cotula*. Figures at the top indicate the number of rays, those at the left the number of heads.



Plant	No. of rays. 10	11	12	13	14	15	16	Total no. heads on each plant.
No. 1	1	6	19	24	2			52
2	1		7	53	10	5		76
3		1	6	9	1			17
4		2	4	11	1	1		19
5			2	11	1			14
6			6	23	5			34
7			6	18	2	8	2	36
8				1	3			4
	2	9	50	150	25	14	2	252

PLATE XVIII.

Plant	No. of rays. 10	11	12	13	14	15	16	Total no. heads on each plant.
No. 1	1	7	2	1				11
2	1		4	10	3			18
3			1	12	1			14
4			1	2	2	3		8
5			1	3	5	2		11
6				1	2			3
7				1	4	1		6
8				1		2	1	4
9				4	2			6
10				5	2			7
11				5	4			9
12				13	3			16
13				4	1	1		6
14				5	3	1		9
15				7	6	1		14
16				2	4	4	1	11
Total no. heads in each class. Sum.	2	7	9	76	42	15	2	153

Wash.

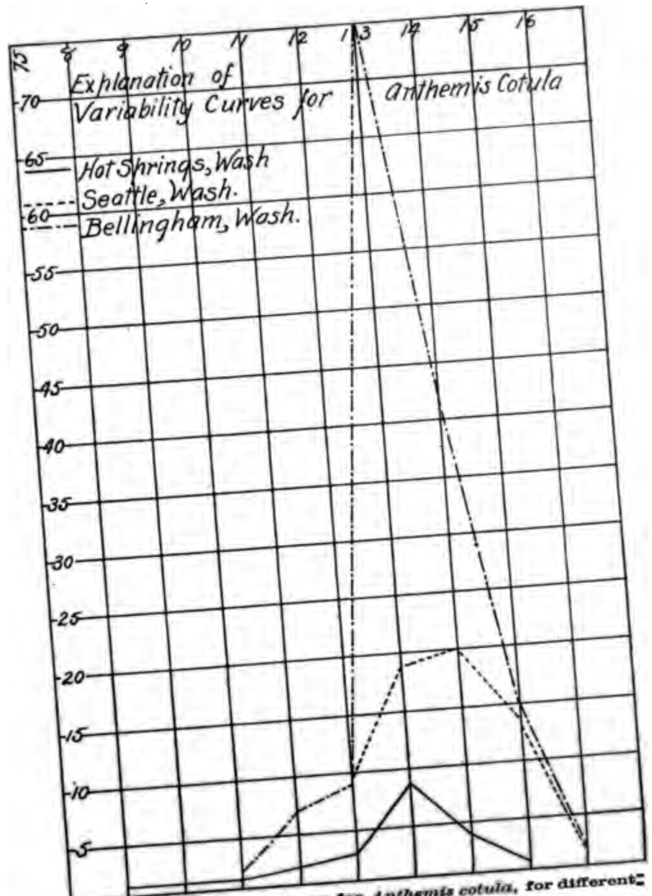
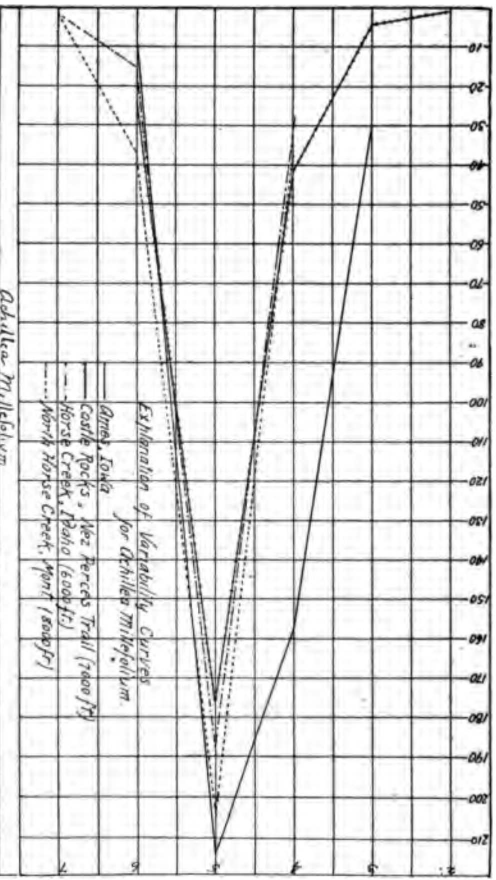


FIG. 2. Variability curves for *Anthemis cotula*, for different localities.

PLATE XIX.



Achillea Millefolium

Localities	No. of rays 2	3	4	5	6	7	Total	a	σ	C
Ames Iowa Just south of College		29	158	219	7		408	4.4877±.0217	.6528±.0154	.1454
Horse Creek Bitter Root Mts. Idaho (6000 ft.)			28	188	15	1	232	4.9353±.0198	.4475±.0140	.0903
North Horse Creek (8000 ft.)			34	205	37	1	277	5.018±.0311	.5226±.0148	.1041
Castle Rock, Nez Perces Trail 7000 ft	1	4	41	178	22		246	4.8780±.0251	.5836±.0177	.1196

FIG. 1. Variability curves for *Achillea millefolium*, different localities.

Plant	No. of rays. 2	3	4	5	6	Total no. heads on each plant.
No. 1	1	1	6	25	3	36
2		1	6	12		19
3		2	3	3		8
4			2	7		9
5			1	10	3	14
6			3	14	1	18
7			5	15	7	27
8			7	17	5	29
9			8	42	3	53
10				8		8
11				7		7
12				18		18
13						
Total no. heads in each class.	1	4	41	177	22	246 Sum

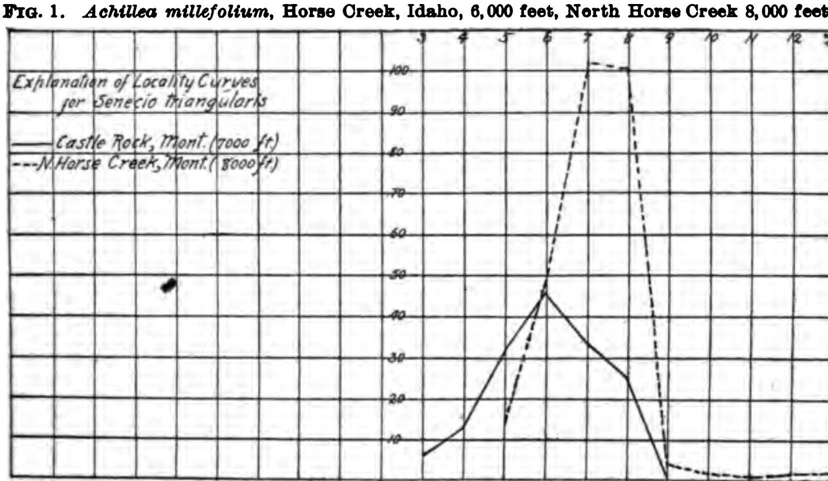
No. of rays. 3	4	5	6	Total no. heads on each plant.
1		12		13
1	3	21	3	28
1	23	4	1	29
2	5	4		11
4	11	8		23
6	23	32		61
14	66	44		124
	1	6		7
	1	7		8
	4	18		22
	9	19		28
	10	13	1	24
	2	26	2	30
29	158	214	7	408 Sum

Total no. heads in each class.

FIG. 2. *Achillea millefolium*, Castle Rock, Nez Perces Trail, Montana and Ames.

Plant	No. of rays. 4	5	6	7	Total no heads on each plant	No. of rays. 4	5	6	7	Total no heads on each plant
No. 1	12	7			19	1	25	2		28
2	7	51	5	1	64	3	9	4		16
3	8	44	3		55	4	11	2		17
4		8			8	7	4			11
5		9			9	9	35	4	1	48
6		9			9	10	56	1		67
7		14	4		18		14	8		22
8		17	1		18		24	7		31
9		29	2		31		24	9		33
Total no heads in each class	28	188	15	1	232 Sum	34	205	37	1	277 Sum

FIG. 1. *Achillea millefolium*, Horse Creek, Idaho, 6,000 feet, North Horse Creek 8,000 feet.



Senecio triangularis

Localities	3	4	5	6	7	8	9	10	11	12	13	Total	a	σ	C
Castle Rock, Mont. (7000 ft)	6	13	32	46	34	26	1					158	6.0822 ± .0717	1.3361 ± .0507	.2200
N. Horse Creek, Mont. (8000)			13	49	102	101	4	2	1	2	2	276	7.2391 ± .0462	1.1392 ± .0327	.1435

FIG. 2. Locality curves for *Senecio triangularis*.

NOTES ON A THERMOPHILIC BACILLUS.

BY R. EARLE BUCHANAN.

That group of plants capable of growth and reproduction at temperatures high above the normal or ordinary has long been an object of interest and study among scientists. An examination of any systematic treatise on the Schizophyceæ will be rewarded by a considerable list of species that grow in hot springs, etc. In Rabenhorst's "Flora Europa Algarum" for instance, there are no fewer than thirteen genera having species or varieties characterized as "thermalis," while others are known to live in water having a temperature of 80°-93° C. Conspicuous and abundant as the Schizophyceæ are in these thermal waters, yet they are accompanied by many less conspicuous forms, the Bacteria, Schizomycetes. These have been discovered and described only since the introduction of modern laboratory technique.

Although these heat loving or heat tolerant Bacteria were first found in thermal waters, more recent investigations have shown that these organisms have a much wider distribution. In the last few years many of this class have been isolated from a variety of sources, such as from soil even to a considerable depth, sewage, feces from both cold and warm blooded animals, dust, straw, dung, snow, air, milk, syrup, cheese and a variety of others. Of course, there is no development of the organism in these substances at ordinary temperatures, the organisms for the most part being spore producers and very resistant.

A careful study of these forms by Schillinger* has shown that they may be separated into two classes, somewhat

*Hyg. Rundschau 8:568. 1898.

arbitrarily it is true, the thermotolerant and the thermophilic. The optimum temperature of the former lies below 40°C. though growth may occur at much higher temperatures, even above 60°C. The optimum of the latter is above 40°C., this being the minimum for most forms. These temperatures, and favorable conditions for the growth of these forms, may be found in many places in nature besides the thermal springs. Even the soil when exposed to the direct rays of the sun is heated sufficiently to enable them to grow. Then, more important, heaps of decaying or fermenting organic matter such as silage or manure develop enough heat in their interior to give the optimum temperature for many.

In order to determine something as to the thermophilic bacterial flora of the manure heap, the study here presented was undertaken. The study has not been completed, and notes are given on one only of the organisms isolated.

Method of Isolation.—A rapidly fermenting heap of horse manure, with an interior temperature of about 58° C., was chosen for the study. Some of this material was removed in a sterile dish, washed with sterile water, and various dilutions used for pouring plates. These latter were incubated at a temperature of 60° to 65° C. for eighteen hours and examined. A large number of colonies had made their appearance in every instance, and seemed to be quite uniform in character, i. e., probably one species was in preponderance. Cultures were made from these colonies on various media, and these incubated at a temperature from 60° to 62° C. A description of this organism follows.

Careful comparison with published descriptions of various thermophilic bacteria showed that probably this organism was the *Bacillus thermophilus* I. of Sames, isolated by him from earth.

MORPHOLOGY.—Rods, motile when young, 3-5 microns long, .6 microns broad, sometimes single, generally in chains of two to ten or more, ends of organism rather truncate. Stains easily and regularly with aniline dyes,

* Hyg. Rundschau 8: 820.

not acid fast. Spores formed in abundance in twenty-four hours or less, polar in position rarely median, do not distend mother cell, from 1.4–1.8 microns long .6 microns broad, readily stained with double stain. These spores are very resistant to dessication and to heat.

CULTURAL CHARACTERS.

Dung Agar Plate Cultures.—Colonies amœboid, in twenty-four hours, $\frac{8}{10}$ mm. in diameter, flat, thin, smooth, colorless to light gray. Under low power of the microscope colonies may be seen to consist of twisted threads of bacteria, edge of colonies rather indefinite, slightly resembling *B. mycoides*, colony soft. Deep colonies similar but better defined. Very often under favorable conditions a few hours were sufficient to cover the plate with a uniform layer of the organisms. Sames notes this character in particular. " Die Platte bei 62° oft schon nach 6 Stunden uberwuchhern und zu dieser Zeit Sporen enthalten."

Nutrient Agar Plate.—Growth resembling that on young agar, but not nearly so luxuriant.

Gelatine.—Gelatine is not peptonized.

Milk.—No change perceptible, though mounts showed the organism to be present in numbers. Growth was not as luxuriant as noted by Sames.

Litmus Lactose Agar Stab.—At the end of twenty-four hours very faint acid tinge. In forty-eight hours lower half of tube partially decolorized, upper half showing decided increase in alkalinity. Growth almost exclusively on the surface, thin, colorless. Spore production particularly abundant.

Potato.—Very little or no growth. Mounts made from the surface of the potato showed the organism to be present in comparatively small numbers.

Bouillon.—Uniform clouding in twenty-four hours, in forty-eight hours, a sediment.

Agar Stab.—Surface growth as in plates. Practically no growth along the deeper portion of a needle track.

Dunham's Solution.—Little growth. Indol faint.

PHYSIOLOGICAL CHARACTERS. *Dessication.*—The spores are capable of withstanding drying for an indefinite period.

Temperature Optimum.—About 60° C. Minimum about 40° C. Maximum about 70° C.

Relation to Oxygen.—The organism is probably a strict ærobe, though a very slight development takes place in glucose agar stabs prepared according to Wright's method.

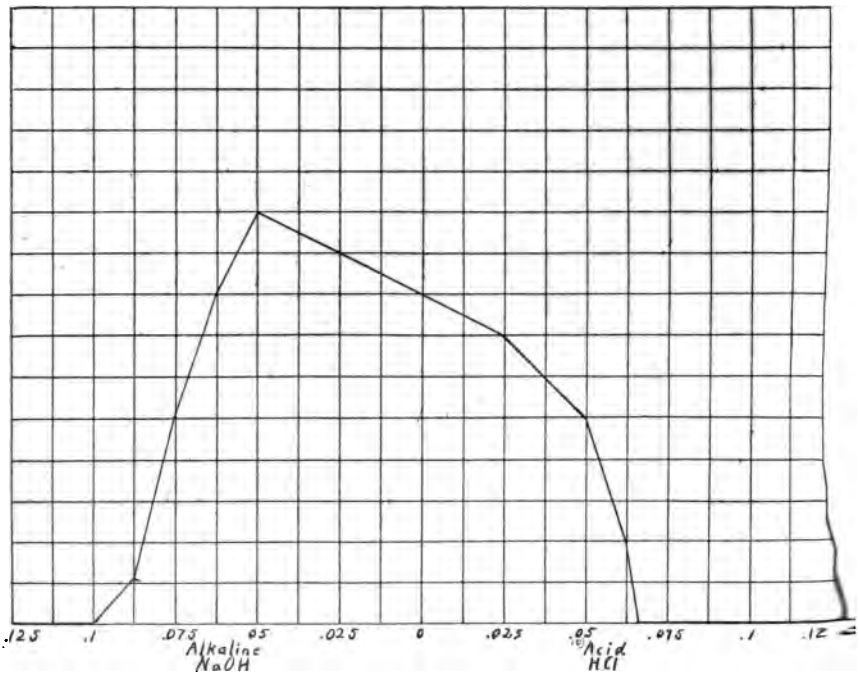


FIG. 3. Curve showing relation of growth to acidity or alkalinity of the medium.

Pigment.—No pigment is produced.

Gas Production.—No gas is produced in dextrose, lactose or saccharose media.

Relation of Growth to Acidity, Alkalinity of Medium.—Bouillon tubes each containing 10 c.c. of Bouillon, exactly neutral to phenol-phthalein were treated with quantities of normal hydrochloric acid and sodium hydrate varying from $\frac{1}{80}$ c.c. to .3 c.c. The above table shows the results in the

PLATE XXI.

FIG. 1. Colonies in agar plate, 18 hours. Natural size.

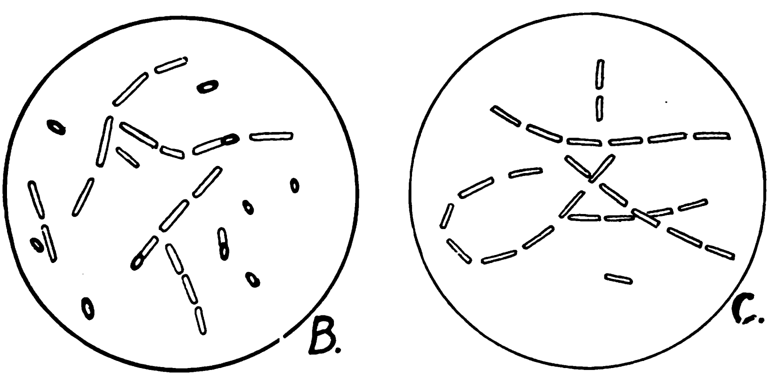


FIG. 2. *B*, Bacilli and spores from agar, 24 hours. *C*, Bacilli, showing chains from bouillon, 18 hours. [Charlotte M. King.]

form of a curve. The amount of growth in the tube containing the most growth was used as a standard, fixed arbitrarily at 10, and the remainder was scaled carefully with this as a basis.

Indol Production.—Negative or very weak. Odor very little if any.

Various media were prepared in order to determine the forms in which nitrogen and carbon are available to the organism as food. As a basis the Stickstoffreie "Mineralische Nährlosung" of Meyer was used.

KH_2PO_4	.1g
$CaCl_2$	.1g
$MgSO_4$-$7H_2O$	.3g
NaCl	.1g
Fe_2Cl_6	.01
H_2O	1000g

To this solution was added various sources of nitrogen and carbon, as is shown, with results, in the following table:

Number.	Source of Nitrogen.	Source of Carbon.	Growth.
1	1 per cent Asparagin	1 per cent Asparagin	None.
2	1 per cent Asparagin	1 per cent Glycerin	None.
3	.05 per cent Asparagin	1 per cent filter paper	None.
4	1 per cent Urea	1 per cent peptone	Good.
5	1 per cent peptone	1 per cent dextrose	Good.
6	1 per cent peptone	1 per cent dextrose	Good.
7	1 per cent peptone	1 per cent lactose	Good.
8	1 per cent peptone	1 per cent saccharose	Good.

It is probable that this organism is incapable of assimilating its nitrogen from any less complex compound than the peptones.

Mikroscopisches Practicum II. 15.

MUNICIPAL HYGIENE—PART I.

BY C. O. BATES.

Allow me to say, by way of introduction, that it is proposed to make this the first of a series of papers on this subject, and for this reason its treatment, at this time, is from a general standpoint rather than a specific.

In His plan of creation God gave to man the gift of health, and endowed him with faculties and surrounded him with agencies for its protection and preservation. Giving man this jewel and the means of guarding it, He laid down irrevocable laws for the punishment of the abuser of the privilege. Thus it is that misery, failure and unhappines are the wages of health laws transgressed; and joy, success and happiness the reward of him who obeys such laws.

"Health, wealth and pursuit of happiness," constitute the sum total of earthly ambitions. In the light of divine law and that of man, health stands paramount, for without it the latter condition can not exist, and the second were mere dross. Science, art, literature, the crafts and every bent of human endeavor and achievement contribute in some form or manner to the uplifting of the race, which has for its basic foundation—health.

In recognition of this fact and by way of proof it is demonstrated that as the race becomes more and more enlightened, in just that proportion does the agitation and the effort to attain health increase. Witness it in sanitary legislation, hygienic methods, formation of "health clubs" and the universal conviction that an erect form, alert step and clean, bright eye are treasures worth more than the fabled wealth of Crœsus.

Such digression is in nowise foreign to the topic which I will briefly treat in this paper. To the contrary it is inseparably related to it, with defining line—if existing—dimly drawn. Thus it is clearly evident that hygienic measures must be encouraged and furthered if best results obtain. And from a health standpoint results are impossible without a warfare against disease.

Japan has achieved wonderful success in her war with Russia. She made a systematic study of the situation before she began war, and knew how to make a specific application of her knowledge in the hour of testing. It is not to the wonderful success, nor the systematic study, nor the specific application, depicted in our daily papers and magazines to which we wish to call attention, but it is to the successful warfare against disease. The small number of fatalities among their wounded soldiers is as great a surprise as the skillful and deadly effect of their firearms. It is said that the Jap behind the microscope is destined to become as famous as the Jap behind the gun.

The etiology of traumatic diseases had its origin in Koch's laboratory a few years ago, and has had its most extended and successful application in the Japanese army during the past twelve months. Japan's success in arms is for the country's immediate welfare as a nation; but her success in combating bacteria is for the welfare of all civilized nations for all future time. One of the immediate effects will be to enlarge and intensify the interest in municipal hygiene.

Social philosophers have for many years deplored the fact that there was a decided tendency for a drift of population from the country to the city. France deplored the idea because of the damage to the rural districts. England deplored the idea because of the evil and unmanageable effect upon the city. For one reason, America deplores the idea on account of the unhealthy condition of the city life.

Statistics, however, have shown that the number of deaths from infected water have been about twice as great

in the rural districts, where no attention was given to the examination and purification of the water, as in the city, where municipal hygiene has been given a fair consideration. All the larger cities and most of the smaller ones have provided themselves with municipal laboratories in which chemical and bacteriological examinations are constantly being made. It stands to reason that in the city with one source of water supply, it would be much easier to examine and purify the water than to examine as many sources of water as there are families scattered over a large territory. It is the duty of the city to take advantage of its hygienic opportunities, because it is not true that the death rate is necessarily higher in the city than in the country.

A comparatively few deaths in one place attract a great deal more attention than many deaths scattered over a large territory. The six hundred people killed at the burning of the Iroquois made a profound impression on our country and the result has been the enactment and enforcement of laws to prevent its recurrence. While the one hundred thousand people that die annually from the effects of tubercle bacteria scarcely receive a passing notice.

Perhaps no other idea has so influenced and moulded our modern civilization as the scientific knowledge of the infinitesimal little plants known as bacteria. In the physical world we have to do with three forces. First, forces between masses, or gravitation; second, forces between molecules, or cohesion and adhesion; third, forces between atoms, or chemical affinity. Upon first thought it might be supposed that the greatest of these forces is gravity, but a little reflection will soon convince one that it is the weakest. Suspend a pencil between the fingers. The force of gravity is unconsciously overcome. To overcome the force of cohesion, it will take considerable effort, but it may be fairly well done by breaking the pencil in two. To overcome the chemical force that exists between the atoms of the pencil no known mechanical force is great enough. A thousand tons might be thrown against it and crush it to

powder, but it would not overcome the force with which the atoms of hydrogen, oxygen and carbon are held together. No hydrogen or oxygen gas would arise from such a stroke simply because the force existing between the atoms, known as chemical force, is so much greater.

It is by means of this, the greatest known physical force, that the little plants make themselves felt. These silent forces are the great forces of the world. Noise is usually the evidence of weakness. Could we but get a rational view of the objects of the microscopical order of magnitude we would indeed see a battle royal in the building up and tearing down of tissues. The sharp contest for holding strategic and vital points, the surprising enfilading movements, and the great evolutions of unnumbered millions make a spectacle more wonderful that the taking of Port Arthur, the battle of Sedan or that of Gettysburg.

Two hundred years ago it was a common belief that certain diseases should be allowed to take their course because it was interfering with the work of Providence to endeavor to prevent them. Smallpox was as universal then as measles and mumps are now. It was expected that everybody would have the smallpox, and if he survived it was evidence that his time to die had not come. There was a time when the average mind reasoned as follows;

"Whatever is universal is right. Certain diseases are universal, therefore, it is right that they should be."

This is not the philosophy of the twentieth century. While the cure of disease has its origin in the remotest antiquity, the prevention of disease is a modern idea. It is not likely that the plagues of the middle ages will ever sweep over our civilization. The art of prevention has too strong a hold on public opinion.

Thirty years ago the source and cause of typhoid fever was shrouded in the deepest mystery. Today this specific germ is well known, its characteristics well understood. The rapid progress in prevention of diseases is paralleled with our growing knowledge of bacteria.

Fellow members of the Iowa Academy of Sciences, it is to you, individually and collectively, I make an appeal for help and guidance in furthering such cause.

There is need of a greater and more general awakening in this matter, there is dire need of legislation upon it, more than all, there is need of a rigid enforcement of such laws when they are enacted. If but a small fractional part of the energy which has been wasted in wrangling over religious creeds and doctrines had been devoted to the real study of the divine laws of nature and a rational explanation of these phenomena as they actually exist, our state of civilization would certainly have been lifted to a higher plane. In municipal hygiene there are three points that demand special consideration; pure water, pure air and pure food. And the greatest of these is pure water.

It is a remarkable fact that men and women are just beginning to awaken to a hygienic consideration of the water question as a solution of the health problem. This awakening, tardy though it be, has given impetus to a movement toward public hygiene which promises to result in a universal demand that hygienic ordinances be adopted by municipalities throughout the length and breadth of the land. Where ten years ago a casual glance would have sufficed the public of today reads with deep interest the report of the condition of the city water.

This warfare against disease is a matter of vital importance, in that it throws a safeguard about home, community and commonwealth.

The time is not far distant when the public in every hamlet, town and city will demand that its hygienic operations be placed under municipal control. Such a course is even now advocated by students, who have spent years of research for methods to meet and solve a problem that is attaining startling proportions.

The problem as presented in Cedar Rapids obtains largely in the water supply, not so much at present with reference to the municipal plant as to neglected wells, to which

is frequently traced the source of contagion. This latter declaration applies directly to rural districts, where milk cans washed with polluted well water take on germs of disease, which are conveyed to the city in the milk. The fact that the city water is no conveyor of disease is due to careful watching, filtration and thorough and frequent cleansing of the filter beds. Through such methods epidemics may be averted.

The Cedar river, which flows through the city, has volume and velocity sufficient to keep it comparatively pure and to prevent the formation of stagnant pools. In fact, the Cedar river is noted for an absence of stagnation. The water, soft in quality, is free from excesses of lime and magnesia.

Our artesian water is furnished by three wells, each about 1,500 feet deep. Water from this source is hard being heavily charged with bi-carbonate of lime and bi-carbonate of magnesia.

Ordinarily about one-fifth of our city water is artesian water, the remaining four-fifths being purified river water.

The artesian water is of such a character as to react chemically on the river water when a small amount of coagulant is used to give a remarkably clear and sparkling product.

Cedar Rapids is exceptionally fortunate in possessing such a unique combination of hygienic and economic agencies.

The filtration plant consists of twelve tanks, each fourteen feet in diameter, with a capacity of 3,000,000 gallons per day. Each tank is thoroughly cleansed twice each twenty-four hours by reversing the current of filtered water back through the sand and floating the solid matter off into the sewers, and also forcing steam through the sand to complete cleansing and to sterilize. When mixed, the water is forced to the top of the tanks, which contain a layer of sand four feet in depth, and by gravity the water filters through the sand, leaving the precipitated alumi-

num saturated with the turbid matter and bacteria. The water collects in a large reservoir beneath, which supplies the city, 2,000,000 gallons being required daily.

Nature's plan of water purification consists of:

Mixing waters,
Filtration and sedimentation,
Action of bacteria upon impurities,
Sunshine and air.

With the exception of sedimentation these processes are in vogue at the local plant as explained above. All correct methods of water purification are imitative of nature, Through the action of water bacteria upon impurities many forms of pollution are removed.

During the first half of this month (April) the water has been in good condition, the gas forming bacteria existing in very small numbers, frequently not at all.

Bacteria coli communis were not found in the water during the time mentioned. In the latter part of February and in March gas forming bacteria were very numerous, among them being found the coli communis. The water bacteria average about four hundred to the cubic centimeter.

The following is the results of my analyses from September to April, inclusive. The bacteriological work did not begin until March. The average of each month is given, and the chemical ingredients are calculated to parts per million. Nitrogen only in nitrogen compounds is given.

Months.	Bacteria.	Free Ammonia.	Alb. Ammonia.	Nitrates.	Nitrites.	Chlorine.	Total solids.	Volatile matter.	Fixed residue.
September	.....	.04	.13	.50	.00	4.5	268	57	211
October	.....	.04	.16	.52	.00	4.5	349	62	287
November	.....	.03	.09	.31	.00	4.4	3	64	250
December	.....	.07	.09	.62	Trace.	4.6	313	64	249
January	.....	.20	.08	.80	Strong.	5.25	346	70	276
February	.....	.48	.05	.25	Strong.	6.25	313	48	275
March	500	.50	20	.60	Strong.	5.20	270	47	223
April	410	.26	.20	.32	Trace.	6.16	322	49	273

The city of Cedar Rapids began by using river water unfiltered. An agitation against its quality resulted in the sinking of artesian wells, which for five years constituted the main source of our water supply. The water being hard, deposited lime incrustations which rendered it unsatisfactory for industrial purposes. For the past ten years we have used a mixed water, as above described, which has proven potable and is used in boilers with satisfactory results.

The amount of artesian water being used in our mains varies, depending upon the season of the year and the condition of the water in the river.

River water, being a variable quantity, holds at intervals considerable suspended matter, and as a result becomes turbid. At other times the water is clear, but such is not a test of its purity.

The first step in municipal hygiene is the purification of water. Every man, be he drone or toiler, is entitled by Divine right to all the pure water he may require. The Scriptures teach us that by the sweat of his brow man shall earn his bread, but they abound in metaphors indicating the purity and freedom of this gift. "Ho, every one that thirsteth, come ye to the waters." "Whosoever will, let him take of the water of life freely."

But advancing civilization has in its haste rendered it impure. Every wrong should be righted, every evil cleared away, so must man render pure again this blessing bestowed upon him.

The lax methods of present day civilization are plainly seen in delayed action, pointing towards sanitary legislation.

Streams reeking with filth and pollution—the sewage of communities upon its banks—are sad commentaries upon our boasted civilization, and are also existing proofs of an almost criminal delay in securing preventive legislation.

To remedy this evil before epidemics become more numerous and intense, some relief must be extended by our lawmakers.

Cities at some points become nothing more or less than repositories for sewage of cities further up the river. In the adoption of some method to dispose of the sewage, other than utilization of the stream, will be found the solution of the problem. Cremation has advantages offered by no other sanitary system. The chemical changes resulting from it remove all danger of infection. All matter is changed to harmless gases or a pure, clean mineral residue. There is no possible chance for disease germs to multiply, as nothing upon which they can subsist remains. While the movement may be slow, public sentiment is surely leaning toward cremation, not only for the safe disposal of certain excreta, but also as the correct and scientific disposition to be made of our bodies. And why should it not? The time is not far distant when the system will be in universal use.

From a health standpoint no more forceful argument in favor of it can be advanced than its absolute annihilation of poisons. On the other hand, exactly opposite conditions are present in interment. The remains, in process of dissolution, offers a field for germs to multiply in the soil, and not infrequently the air and water are impregnated with poisonous matter. Society is overcoming its prejudice to the system of cremation. This is attributed to the fact that the custom and tradition are being modified by the advance of science. The entire trend of scientific research on bacteriological lines during the past twenty years has been a combat with germs. And as research progresses, so does the sentiment in favor of cremation grow. Germs are effectively destroyed by heat. No more telling argument can be presented for cremation.

So far as the disposal of our sewage is concerned, the septic tanks that are in use in many places are perhaps the best that can be done at present. More will be said of this at some other time.

If it were not for the purifying agencies of nature, it seems that the human race would have become almost extinct on account of carelessness in regard to sanitary regu-

lations. Especially was this true in the middle ages in the large cities. During the time of Queen Elizabeth, Paris and London have been described by historians as follows:

"The old Greek and Roman religion of external cleanliness was turned into a sin. The outward and visible sign of sanctity now was to be unclean. No one was clean, but the devout Christian was unutterably foul. The tone of the middle ages in the matter of dirt was a form of mental disease. Cooped up in castles and walled cities, with narrow courts and sunless alleys, they would pass day and night in the same clothes, within the same airless, gloomy, windowless and pestiferous chambers; they would go to bed without night clothes, and sleep under uncleansed sheepskins and frieze rugs; they would wear the same leather, fur and woolen garments for a lifetime, and even for successive generations; they ate their meals without forks, and covered up the orts with rushes; they flung their refuse out of the window into the street or piled it up in the back yard; the streets were narrow, unpaved, crooked lanes through which, under the very palace turrets, men and beasts tramped knee-deep in noisome mire. This was at intervals varied with fetid rivulets and open cesspools; every church was crammed with rotting corpses and surrounded with graveyards, sodden with cadaveric liquids, and strewn with disinterred bones. Round these charnel houses and pestiferous churches were piled old decaying wooden houses, their sole air being these deadly exhalations, and their sole water supply being these polluted streams or wells dug in this reeking soil. Even in the palaces and castles of the rich the same bestial habits prevailed. Prisoners rotted in noisome dungeons under the banqueting hall; corpses were buried under the floor of the private chapel; scores of soldiers and attendants slept in gangs for months together in the same hall or guardroom where they ate and drank, played and fought."

This is a dark picture, but no doubt a faithful description of the sanitary conditions of that age.

Shall future ages look back on us with the same feeling that we look back on the past?

Let the beginning of the twentieth century mark the beginning of a new era in sanitary regulations.

Let us encourage every organization that has for its object the fostering of such regulations, anti-tuberculosis societies, health clubs, etc., and as a matter that may more directly concern us, demand more scientific investigations on the part of our commonwealth. We have a geological survey in all sections of our state; let us, as members of the Academy of Sciences, call for a bacteriological, biological and chemical survey of the various water basins, so that we may know what to expect and how to combat the deleterious agencies in the water.

It is absolutely necessary to take all these matters into consideration, the past with its woes, the present with its glaring needs, before we can take an intelligent, optimistic view of the future.

Before closing, I desire to emphasize the need of progressive sentiment demanding that boards of health exercise their prerogatives and that in fulfillment of duty they will be given the moral support of all citizens. The public health is in the hands of its especially appointed boards, and it is a sacred duty of such officials to exhaust every resource at their command to fulfill the trust reposed in them. Germs of typhoid in wells, diphtheria in the air, cholera and tuberculosis in food, demand earnest, vigorous, progressive, intelligent work on the part of the board of health. In their hands is the power to avert the slaughter of the innocents.

NOTES ON THE FLORA, ESPECIALLY THE FOREST FLORA, OF THE BITTER ROOT MOUNTAINS.

BY L. H. PAMMEL.

During the past summer a hasty survey was made of that part of the Bitter Root mountains west and south of Hamilton. The range on the whole is not a lofty one, the highest peaks being about eleven thousand feet high. The mountains are fairly well timbered. There are few lakes and comparatively few meadows in the area visited.

The lower foothills consist of bare slopes with a few trees. These consist of scattered groves of *Pinus ponderosa*, common xerophytic plants like *Artemisia tridentata*, *Purshia tridentata*, and *Achillea millefolium*. The benches on the west slope of the mountains were once thickly covered with *Pinus ponderosa*, which has largely been removed through the operation of large lumber companies.

There is a well marked zonal distribution of the several conifers found in these mountains. The lower zone is occupied by the *Pinus ponderosa*, followed by the *Pseudotsuga douglasii*. This is followed by the *Pinus murrayana*. The *Pinus albicaulis* occupies the upper zone of the Lodge Pole pine region. *Picea engelmannii* and *Abies subalpina* occur in the canons and narrow valleys of the streams extending over a considerable altitude, from four thousand feet to timber line.

THE PINUS PONDEROSA ZONE.

The Yellow pine has admirably adapted itself to all the lower, drier slopes; much of this is very rocky. The soil is rather thin, but well drained. The young trees are usually

scattered in the forest, but where protected they grow as thickly as the Lodge Pole pine. This pine makes a fairly rapid growth as is shown in the table on the following page:

The Bitter Root forest reserve is partly located in Montana and partly in Idaho. The eastern part of the reserve has its watershed in the Bitter Root valley, in the western part of the reserve the water flows to the Clear Water and the Salmon rivers.

It is not my purpose to treat the topography of the region as this has been done in an excellent paper by J. B. Leiberg. Incidentally Mr. Leiberg* touches some ecological phases of this forested area. There is also a good account of the ecological phases of the Priest River Forest reserve.† Dr. Whitford‡ has given an excellent account of the forest region of the Flathead country.

The drainage of all the streams is of course toward the Pacific Ocean. The East Fork empties into the Bitter Root river. Warm Springs creek flows into East Fork, the Overwhich creek flows into the South Fork and this in turn into the Nez Perces Fork which now commonly is considered a continuation of the South Fork. The latter really terminates at the West Fork. Horse creek has its source on the divide between Montana and Idaho at an altitude of 8,000 to 8,500 feet. This stream empties into the Salmon river. The highest divide continues beyond the old Nez Perces trail. The headwaters of the Clear Water reaches the Montana boundary. The rocks of this region consist of quartzites and felsitic rocks. Leiberg, in the paper referred to, establishes two forest zones, the Yellow Pine and Subalpine zones; of the 787,200 acres about twenty-six per cent belongs to the latter zone, while seventy-four per cent to the former. The most important timber species is the Yellow pine, *Pinus ponderosa.*

*The Bitter Root Forest Reserve. U. S. Geol. Survey. 19: 253.

†U. S. Geol. Survey. 19: 217.

‡Bot. Gazette 39: 194.

GROWTH OF YOUNG PINUS PONDEROSA ON BOULDER CREEK.

	Year.						
	1904.	1903.	1902.	1901.	1900.	1899.	
Inches	7	6	4	5	4	3	
Inches	11	12	7	4	5	3	
Inches	10	8	10	4	6	4	
Inches	8	7	3	6	5	4	
Inches	6	8	6	4	5	6	
Inches	4	3	3	4	7	5	4 ft. H.
Inches	6	9	5	5	4		
Inches	10	7	7	3	3	3	3 ft. H.
Inches	6	7	6	4	3	2	
Inches	6	10	8	7	7	6	
Inches	7	1[illegible]	10	10	11	8	10 ft. H
Inches	7	6	8	7	7	7	4 ft. H

During the first few years the annual growth in length is much less than when a young tree attains the height of eight or ten feet. The number and size of trees growing in an open forest on Boulder creek at an altitude of five thousand feet was as follows:

THE DIAMETER AND HEIGHT OF PINUS PONDEROSA COMPARED WITH OTHER SPECIES.

Species.	Diameter in Inches	Height in Feet.
Pinus ponderosa	24	90
Pinus ponderosa	25	90
Pinus ponderosa	28	94
Pinus ponderosa	16	75
Pinus ponderosa	21	75
Pinus ponderosa	22	75
Pinus ponderosa	21	70
Pinus ponderosa	21	65
Pinus ponderosa	12	50
Pinus ponderosa	6	40
Pseudotsuga douglasii	8	50
Pseudotsuga douglasii	12	60
Pseudotsuga douglasii	18	65
Pseudotsuga douglasii	6	50
Pseudotsuga douglasii	4	35
Pseudotsuga douglasii	4	35
Pinus murrayana	11	45
Pinus murrayana	10	50
Picea pungens	6	40
Picea pungens	4	35

PERCENTAGE OF SPECIES AT 5,000 FEET ALTITUDE ON BOULDER CREEK.

In the same area the percentage of species found is shown in the following table:

Pinus murrayana	10.8
Pinus ponderosa	56.6
Pseudotsuga douglasii	26.2
Picea engelmannii	6.4

Between five and six thousand feet altitude on the north fork of the West Bitter Root the *P. ponderosa* is less abundant, as may be seen from the following table:

DOMINANT SPECIES.

Species.	Per Cent.	Per Cent.	Altitude.	Location.
Pinus ponderosa	64	30	5 500	Flat.
Pinus murrayana	6	6	5,500	Flat.
Abies subalpina	2	2	5,500	Flat.
Pseudotsuga douglasii	26	60	5,500	Flat.
Populus tremuloides	1	2	5,500	Flat.
Populus balsamifera	1	2	5,500	Flat.

DOMINANT SPECIES.

Species.	Per Cent.	Altitude.	Location.
Pinus ponderosa	5	6,500	Side of mountain.
Pinus murrayana	10	6 500	Side of mountain.
Abies subalpina	2	6,500	Side of mountain.
Pseudotsuga douglasii	73	6,500	Side of mountain.

DOMINANT SPECIES.

Species.	Per Cent.	Altitude.	Location.
Pinus murrayana	8.2	4,200	In swamps.
Pinus ponderosa	15.2	4,200	In swamps.
Abies subalpina	30	4,200	In swamps.
Pseudotsuga douglasii	14.4	4,200	In swamps.
Picea	72.2	4,200	In swamps.
Populus balsamifera	10	4,200	In swamps.

The plants of the *Pinus ponderosa* woods consist of *Rubus nutkanus, Prunus demissa, Philadelphus microphyllus, Amelanchier alnifolia, Betula occidentalis, Geranium fremontii, Berberis repens.* In the swamps along the streams, *Rubus nutkanus, Aconitum columbianum, Alnus incana* var. *virescens, Betula occidentalis, Erigeron corymbosus, E. glabellus,* and *E. salsuginosus, Aster adscendens* and *Dodecatheon media, Bromus marginatus, Amelanchier alnifolia, Pedicularis groenlandica* and *Ledum glandulosum, Heracleum lanatum, Thalictrum sparsiflorum, Symphoricarpos racemosus, Parnassia palustris, Lonicera involucrata* and *Cratægus rivularis.*

Between 5,000 and 6,000 feet on Overwhich creek there are few open marshes. Along the banks of the streams the following plants were noted:

Dodecatheon media, Mimulus lewisii, Calamagrostis hyperborea, Pyrus arbutifolia, Aconitum columbianum, Thalictrum sparsiflorum, Saxifraga virginiensis, Ledum glandulosum, Lonicera involucrata, Angelica lyalli, Ligusticum apiifolium.

DOUGLAS SPRUCE ZONE.

The Pseudotsuga zone occurs beyond the *Pinus ponderosa*, although the two overlap. The Douglas Spruce occurs in more shady and moist situations. The dominance of the different species of conifers is shown in the following table:

DOMINANT SPECIES IN THE DOUGLAS SPRUCE ZONE.

Species.	Per Cent.	Altitude.	Locat
Peusdotsuga douglasii	80	6,800	Side h
" "	50	6,800	Side h
" "	74.4	6,800	Side h
" "	39.6	6,800	Side h
" "	72	6,800	Side h
" "	4	7,200	Side h
" "	24.8	7,200	Side h
" "	32.4	7,200	Side h
" "	58.1	7,200	Side h
Pinus murrayana	5	6,800	Side h
" "	30	6,800	Side h
" "	50	6,800	Side h
" "	28.2	6,800	Side h
" "	34	6,800	Side h
" "	18.6	6,800	Side h
" "	59.4	6,800	Side h
" "	52	7,200	Side h
" "	31	7,200	Side h
" "	54	7,200	Side h
Pinus flexilis	2.5	6,800	Side h
" "	0	6,800	Side h
" "	0	6,800	Side h
" "	0	6,800	Side h
" "	0	6,800	Side h
" "	50	6,800	Side h
" "	30	6,800	Side h
" "	0	6,800	Side h
" "	24	7,200	Side h
" "	31	7,200	Side h
" "	0	7,200	Side h
" "	41.5	7,200	Side h
" "	20	7,200	Side h
" "	28.2	7,200	Side h
Abies subalpina	2.5	6,800	Side h
" "	16.5	6,800	Side h
" "	6.2	6,800	Side h
" "	0	6,800	Side h
" "	12	6,800	Side h
" "	16	7,200	Side h
" "	12.4	7,200	Side h
" "	12	7,200	Side h
" "	0	7,200	Side h
" "	0	7,200	Side h
" "	0	7,200	Side h
" "	42.3	7,200	Side h
Picea	14	7,200	Side h
"	0	7,200	Side h
"	0	7,200	Side h
"	0	7,200	Side h
"	0	7,200	Side h
"	20	7,200	Side h

Some of the most abundant plants found in the open woods are as follows: *Balsamorrhiza sagittata* is especially abundant on the dry slopes. This species frequently covers the side of the mountains. The *Delphinium scopulorum* forms great masses in the open woods with *Amelanchier alnifolia* and *Symphoricarpos racemosus.* The most abundant grass is *Agropyron dasystachyum. Epilobium spicatum, Cnicus drummondii* and *Arnica cordifolia* occur in the open woods. The *Cnicus drummondii* in small open meadows. In these may also be found the *Erigeron salsuginosus. Shepherdia canadensis,* and *Juniperus communis* are common throughout the woods. The *Epilobium spicatum* and *Cnicus drummondii* are the most common fire weeds occurring where fires have burned the timber.

THE PINUS MURRAYANA ZONE.

This species has a much wider range than the Pseudotsuga or the *Pinus ponderosa.* It ranges in altitude from 4,500 feet to timber line. At lower altitudes it occurs in the flood plains of the streams.

It reaches its maximum development beyond the Pseudotsuga zone. The following table shows the dominance of species:

DOMINANCE OF SPECIES IN PINUS MURRAYANA ZONE.

Specimen.	Per cent.	Altitude.	Location.
Pinus murrayana	75	7,800	Flat.
" "	7.1	7,800	Sunny side of Mt., E. slope.
" "	35.8	7,800	Shady side of Mt. on slope.
" "	46.2	7,800	Flat.
" "	60.5	7,800	Flat.
" "	30.4	8,000	Flat.
" "	9.3	7,000	Flat.
" "	18.6	7,000	Flat.
" "	27	7,000	Flat.
" "	91.2	7,000	Flat.
" "	99.2	7,000	Flat.
" "	8.12	7,000	Flat.
" "	56.4	7,000	Flat.
" "	66	7,000	Flat.
" "	29	7,000	Flat.
P. albicaulis	5	8,000	Flat.
" "	35.5	7,800	Sunny side of Mt., E. slope.
" "	34.8	7,800	Sunny side of Mt., N. slope.
" "	30 2	7,800	Flat.
" "	17	7,800	Flat.
" "	22.8	8,000	Flat.
" "	9.4	7,000	Flat.
" "	22	7,000	Flat.
" "	5.4	7,000	Flat.
" "	55.5	7,000	Flat.
" "	25	7,000	Flat.
" "	16.6	7,000	Flat.
P. flexilis	21.3	7,000	Flat.
" "	22.8	8,000	Flat.
Abies subalpina	12	7,800	Flat.
" "	14.2	7,800	Sunny side, E. slope.
" "	29	7,800	Sunny side of Mt., N. slope.
" "	13.2	7,800	Flat,
" "	16.5	7,800	Flat.
" "	30.4	8,000	Flat.
" "	6.2	7,000	Flat.
" "	80.6	7,000	Flat.
" "	72	7,000	Flat.
" "	76	7,000	Flat.
" "	17.4	7,000	Flat.
" "	32.9	7,000	Flat.
" "	9.4	7,000	Flat.
" "	11	7,000	Flat.
" "	108.9	7,000	Flat.
" "	5.4	7,000	Flat.
Picea	8	7,800	Flat.
"	42.6	7,800	Side of Mt., N. slope.
"	110.4	7,800	Sunny side of Mt., E. slope.
"	5.5	7.800	Flat.
	16.4	8,000	Flat.

ANNUAL GROWTH OF DIFFERENT CONIFERS.

The growth of *Pinus murrayana P. albicaulis, Abies subalpina* and *Picea engelmannii* is comparatively small during the early life of the species.

GROWTH OF CONIFERS AT AN ALTITUDE OF 8,000 FEET, NORTH FORK OF HORSE CREEK.

GROWTH OF PINUS MURRAYANA.

H.	D.	1899.	1900.	1901.	1902.	1903.	1904.	Age.
14 in.	⅛	....	....	....	1½	1½	2½	
10 in.	⅛	....	....	....	1	2	3	
....	....	2	1	2	3	3	3	
....	....	....	2½	3	4	5	6	
10 in.	⅛	....	......	....	1⅛	1	3	9

GROWTH OF PINUS ALBICAULIS.

H.	D.	1899.	1900.	1901.	1902.	1903.	1904.	Age.
19 in.	¼	....	1-½	½	1	2	3	
36 in.	1- ½	....	....	....	3	2	4	10
10 ft.	2	....	....	4	4	5	8	30
3 ft.	1-14	....	....	1	2	2	4	10
10 in.	....	....	....	1-½	1-½	1	2	8
6 in.	....	....	....	....	1	1	¼	6
6 in.	....	2-½	2-¼	2	2	3	3	

GROWTH OF ABIES SUBALPINA.

H.	D.	1898.	1899.	1900.	1901.	1902.	1903.	1904.	Age.
20 ft.	4 in.	......	......	2½	23	43	2½	2½	
5 ft.	2 in.	......	......	......	4	6	4	6	
45 in.	2½	......	......	2	1	5	4	6	
36 in.	2⅛	....	......	4	¼	4	3	2	
45 in.	3	......	......	2	2	4	3	4	Double leader.
45 in.	3	......	......	3	1	2	4	3	

GROWTH OF PICEA ENGELMANNII.

H.	D.	1898.	1899.	1900.	1901.	1902.	1903.	1904.	Age.
7 ft.	4	2	2	2	2	5	5	5	30 yrs.
8 ft.	3	......	3	3	3	4	2	3	
8 ft.	2	......	......	....	3	4	3	2	
10 ft.	5	.....	......	5	3	3	12	6	
38 in.	¾	......	4	1½	2	2½	3	4	
14 in	¼	......	......	......	½	2	2	3	
8 ft.	3	......	......	6	3	7	10	5	
9 in.	¼	......	......	......	1	1¼	2	......	

TOTAL GROWTH OF SEVERAL SPECIES OF CONIFERS.

Name of Species.	Diameter. Inches.	Height. Feet.	Age.	Altitude.
Pinus albicaulis	12	32	....	8,000
Pinus albicaulis	8	24	....	8,000
Pinus albicaulis	18	45	66	8,000
Pinns albicaulis	9	38	60	8,000
Pinus albicaulis	14	51	130	8,000
Pinus albicaulis	8½	33	80	8,000
Pinus albicaulis	10	33	80	8,000
Abies subalpina	5	18	20	8,000
Pinus murrayana	8	32	30	....
Pinus murrayana	7½	10	35	....
Pinus murrayana	1	3½	18	....
Pinus murrayana	1¾	5	17	....
Pinus murrayana	9	8	30	....
Pinus murrayana	7½	10	35	....

The region at an altitude of 8,000 feet is quite heavily timbered. There are but few small open meadows. In these open meadows, such plants as *Achillea millefolium*, *Arnica cordifolia*, *Aquilegia cærulea*, *Deschampsia cæspitosa*, Erigeron several species, *Valeriana sylvatica*, Luzula two species. The banks of the small streams were lined with *Bryanthus empetrifolia* scattered here and there in the meadows, but more abundant in the woods is what is known as Moose Grass (*Xerophyllum douglasii*), Gilia, Arnica, *Geum triflorum*. The Englemann Spruce, *Pinus albicaulis*, *Abies subalpina*, and the *Pinus murrayana* extend to the timber line in some places. The real timber line species here appears to be the white pine. The highest point reached on the trip was about 8,500 feet. The Moose Grass, *Xerophyllum douglasii*, also reaches the timber line. There were also several species of Poa, Danthonia, *Bryanthus empetrifolia*, Vaccinum two species, the *V. cæspitosum* and the *V. myrtillus* var. *microphyllum*, *Ledum glandulosum*, and a cæspitose Phlox.

There are very few open parks in this country. The most extensive visited was at an altitude of 7,500 feet near the head waters of the Blue Joint. At this point occurring on the outlying lower slopes are groves of the *Pseudotsuga douglasii* and *P. murrayana;* farther up on the highest points some *Abies subalpina*, *P. albicaulis*, and a little

Englemann Spruce. The most abundant of all, however, was the Lodge Pole pine. In these open meadows there was an abundance of *Agropyron dasystachyum*, *Linum lewisii*, *Eriogonum umbellatum*, *Poa pratensis* and other Poas. *Achillea millefolium*, Antennaria and two species of blue-flowered Aster, and *Gnaphalium sprengelii*. On the wooded slopes along one of the branches of the Clear Water are fine forests and individual specimens of *Abies subalpina*, here, too, are found fine specimens of *Picea englemannii*.

Overhanging the brooks in moist places an abundance of several species of Asters, Erigerons, the *Saxifraga punctata*, *Aconitum columbianum*, *Luzula spadicea*, *Aspidium lonchitis*, *Asplenium septentrionale*.

Large, prominent, isolated rocks are more or less frequent in Idaho and Montana in the Bitter Root range. One of the most conspicuous of these is known as Castle Rock. The vegetation here is entirely xerophytic. Growing on the tops of these rocks there are a few scattered white pine, *P. albicaulis*. One of the largest of these was twenty feet high, thirty inches in diameter, with an estimated age of about five hundred years. *Juniperus communis* was common over the entire mountain, and especially over the talus coming from the rocks. The rocks were covered with yellow lichens. These were so abundant as to be noticeable from a distance of one-half mile. The *Woodsia oregana*, *Pellæa breweri* are abundant, also a small species of Erigeron, and *Sibbaldia procumbens*. *Heuchera cylindrica*, *Ribes lacustre*, *Vaccinium myrtillus* var. *microphyllum*, *Rubus strigosus* and *R. nutkanus*. Small plants of the Quaking Aspen (*Populus tremuloides*), *Pyrus arbutifolia* and *Pyrus sambucifolia* were abundant where erosion and disintegration had broken up the rock. In small meadows below plants like *Mimulus lewisii*, *Angelica lyallii*, *Archangelica gmelini*, *Cicuta occidentale*, *Veratrum californicum*, *Calamagrostis hyperborea* and Bromus sp. were abundant.

PINUS ALBICAULIS ZONE.

The *Pinus albicaulis* extends down into the canon, but attains its great development on the flats and slight slopes, the highest points being between 8,500 and 9,000 feet. The species is frequently dwarfed, but not nearly so much as the Spruce at a higher altitude. At points below 8,500 feet it is somewhat stunted, attaining a considerable diameter and low height as the following table will show.

HEIGHT AND DIAMETER OF THE PINUS ALBICAULIS, NORTH FORK OF HORSE CREEK.

Location.	Height.	Diameter.	Altitude.
Flat	50 feet	2 feet	8,500
North slope	60 feet	2½ feet	8,500
West slope	50 feet	2½ feet	8,500

The percentage of conifers is shown in the following table:

DOMINANCE OF SPECIES IN PINUS ALBICAULIS ZONE.

Species.	Per Cent.	Altitude.	Location.
Pinus murrayana	24.5	7,800	Flat.
" "	23.2	8,000	Flat.
" "	22.2	8,500	Flat.
" "	68.4	8,500	Slight slope north.
" "	2 40	8 000	Slope to north, side hill.
Pinus albicaulis	50.4	7,800	Flat.
" "	58.8	8,000	Flat.
" "	60	8,500	Side slope, north.
" "	80	8;500	Side slope, north.
" "	15.2	8,500	Side slope, north.
" "	33.3	8,500	Side slope, north.
" "	66.6	8,500	Side slope, north.
Abies subalpina	9	7,800	Side slope, north.
" "	17.4	7,800	Side slope, north.
" "	40	8,500	Flat.
" "	12.9	8,500	Flat.
" "	33.6	8,000	Side hill, slope north.
" "	5	8,000	Side hill, slope north.
" "	12.9	8,000	Side hill, slope north.
Picea engelmannii	13.5	7,800	Flat.
" "	0	8,000	Flat.
" "	20	8,500	Slight slope north.
" "	33.6	8,000	Side hill, slope to north.
" "	60	8,000	Side hill, slope to north.

SOME INTRODUCED AND WEEDY PLANTS.

The irrigated and lower unirrigated districts contain a large number of foreign weedy plants. The more conspicuous of the weedy plants of grain fields are such as are common to all the inter-mountain country. The *Avena fatua*, *Saponaria vaccaria*, *Lychnis githago*, *Helianthus petiolaris*, and *H. annuus*, *Brassica sinapistrum*. The more common of the street and roadside weeds observed were as follows: The *Sisymbrium altissimum* was as common in the streets of Hamilton as *Brassica sinapistrum* is in eastern North Dakota or along the roadsides in Iowa. *Cnicus lanceolatus*, abundant not only in the streets but in dry places along the roadsides. *Rumex acetosella*, *Chenopodium album*, *Salsola kali* var. *tragus*, *Cnicus canescens*, *Verbascum thapsus*, *V. blattaria* and *Lactuca pulchella* were common not only along roadsides where the soil was occasionally irrigated, but in very dry soils. The Black Henbane (*Hyoscyanus niger*) was found in one place along the roadside close to the mouth of the west branch of the Bitter Root river.

It is interesting to make a comparison of the weedy plants found near Deer Lodge, Montana, the Deer Lodge being a tributary of the Hellgate, which in turn empties into the Missoula.

The *Avena fatua*, *Saponaria vaccaria*, *Lychnis githago*, *Helianthus petiolaris*, *H. annuus*, *Hordeum jubatum*, *Brassica sinapistrum*, *Salsola kali* var. *tragus*, are common not only in Deer Lodge but near Livingston, Billings, Miles City and Glendive on the Atlantic slope.

Oxytropis lamberti, *Hedysarum boreale*, *Lygodesmia juncea*, *Malvastrum coccineum*, *Solidago serotina* were abundant in fields and waste places in the Deer Lodge Valley. On the Atlantic slope the following conspicuous weeds were observed: *Cleome integrifolia*, *Grindelia squarrosa*, *Amaranthus retroflexus* *A. blitoides*, *Lactuca scariola*, *Iva xanthiifolia*, *I. axillaris*, and *Malvastrum coccineum*.

THE LIMITS OF CULTIVATED PLANTS.

Some of the cultivated plants, especially the forage plants, have been widely naturalized. *Trifolium pratense*, *T. repens*, *Phleum pratense* and *Poa pratensis* have followed the trails far beyond present limits of the cultivated areas. The clovers are found miles beyond the settlements. Frequently along old trails or where lumbering operations were formerly carried on. Fruit culture is successful in the Bitter Root Valley and its tributaries up to altitudes somewhat above 4,000 feet. Orchards have been planted where frosts occur nearly every week in the year. The culture of the potato occurs at altitudes somewhat higher than the apple. Cherries (*Prunus cerasus*), *Prunus domestica* and Peaches succeed in the Bitter Root Valley.

PLATE XXII.

FIG. 1. Yellow pine (*Pinus ponderosa*) slope, Boulder Creek: middle

FIG. 2. *Pseudotsuga douglassii* on the lower dry slopes of Horse Creek

PLATE XXIII.

FIG. 1. *Mimulus lewisii*, *Aconitum* in open meadow, border of *Pinus*

FIG. 2. *Ceanothus velutinus* and [illegible]

PLATE XXIV.

PLATE XXV.

PLATE XXVI.

FIG. 1. White Pine (*Pinus albicaulis*) top of Castle Rock 7,200 feet;

FIG. 2. White Pine (*Pinus albicaulis*) Hughe's creek, Montana.

PLATE XXVII.

METHODS FOR THE ESTIMATION OF CARBON DIOXIDE IN MINERALS AND ROCKS.

BY NICHOLAS KNIGHT.

There seems to be two principal methods employed for the estimation of carbon dioxide in a mineral or rock; the one devised by Fresenius and the other by his rival Bunsen. The Fresenius method has been more or less modified by different analysts. In its essential features, however, it is substantially as follows: The flask *K* for the decomposition of the substance has a capacity of 200 to 300 c.c. The flask is closed with a two-hole rubber stopper. The safety tube *a* passes through one hole, and a bulb tube *b* through the other. A funnel is connected with the safety tube at *a* by a rubber tube. Thus the addition of acid can be regulated by the pinch cock at *o*. *d* and *e* contain soda lime and caustic potash respectively. These are connected with the safety tube after the acid has been added and the substance in the flask *K* has been dissolved. The bulb tube *b* serves to condense the steam.

The first U-tube, *f*, contains calcium chloride in its lower portion and the second tube, *g*, is filled with granular calcium chloride. These tubes remove the moisture. To absorb the hydrogen chloride, the tube *h* contains small pieces of pumice stone which have been boiled in a concentrated solution of copper sulphate and afterwards dried in the air bath at 250° to 300° C. A calcium chloride tube, *i*, is connected with *h*. The carbon dioxide is absorbed by the two U-tubes *k* and *l*. They are 11 cm. long and 12 mm. in diameter, and are ⅞ full of coarse soda lime, the remaining space containing calcium chloride. To prevent backward diffusion of carbon dioxide or water, the tube *w* is filled with calcium chloride on the side next the appara-

tus and with soda lime on the other side. The bend of the tube *n* is filled with water which makes it possible to observe the rate of the reaction.

The absorption tubes *k* and *l* are weighed and two or three grams of the substance are placed in the decomposing flask, then the apparatus is tested to learn if all the joints are tight. Dilute hydrochloric acid is slowly added from *c*. When the action has ceased, the funnel *c* is removed and the tube *d* is connected with the funnel tube *a*, and a slow current of air is aspirated through the apparatus, while the flask *K* is heated until the liquid boils. This sweeps the carbon dioxide into the absorption tubes. When the apparatus is thoroughly cooled the tubes *k* and *l* are weighed, the increase representing the amount of carbon dioxide in the specimen. Some recommend the use of only one soda lime tube, but two make the absorption of all the carbon dioxide more certain.

One of the principal difficulties in connection with this method is the possibility of the escape of the carbon dioxide through the numerous rubber connections. Every one who has made an ultimate analysis by combustion understands how constant a source of error the joints are, and how carefully one must guard losses through the walls of rubber tubing.

A much simpler method than the one described was devised by Bunsen, shown in Fig. 2. This method is not usually described in the text-books. A gram of the finely pulverized substance is weighed into the flask, *d*. The bulb *c* is nearly filled with a mixture of one part concentrated hydrochloric acid and three parts water. The bulb *h* contains cotton which assists in condensing the vapor. Attached to the bulb is a small tube filled with fused calcium chloride. The apparatus from *c* to *e* inclusive is carefully weighed. By means of a rubber tube attached to the calcium chloride tube *e*, the dilute acid is started into the flask *d* by suction with the mouth. When all the liquid has passed over, the apparatus is held in the hand and gently warmed, until the powder is dissolved or effervescence ceases. The apparatus is then connected

PLATE XXVIII.

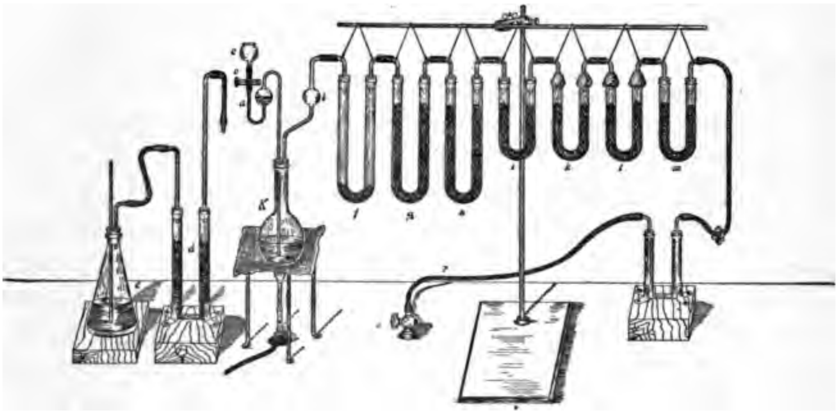


FIG. 1. The method of Fresenius.

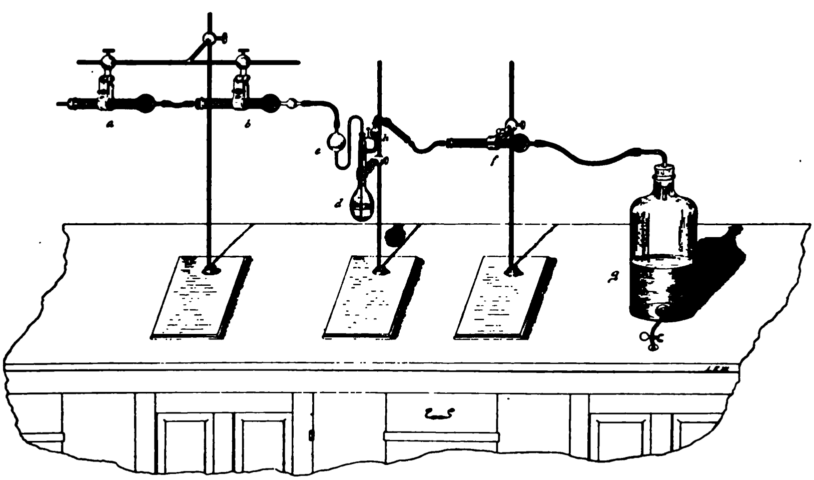


FIG. 2. The Bunsen method.

with two freshly filled calcium chloride tubes on one side and a calcium chloride tube and aspirator on the other side as shown in the figure. Air is drawn through the apparatus for about twenty minutes while the flask *d* is immersed in a beaker of distilled water to cool it. The apparatus is carefully wiped with silk and weighed, the loss, of course, representing the amount of carbon dioxide. The apparatus is gently warmed again, and the air aspirated through as before while the flask is in the beaker of distilled water. A weight that is practically constant is readily attained.

The writer has made scores of determinations by this method, and has supervised hundreds more that have been made by students, especially in Iceland spar, dolomite and siderite. There is not much difficulty in securing a result that differs not more than one-tenth of a per cent from the theoretical. It might seem that there would be a tendency to get too high a result, but such is not the case, providing the rock substance has been sufficiently pulverized, and the calcium chloride in tube *e* is of good quality and is changed sufficiently often to keep it in proper condition. Besides, the acid becomes further diluted as soon as it begins to act on the powder, and at first the action takes place with very little heat.

Where it is desirable to make a carbon dioxide determination in a sulphide like chalcopyrite, it is necessary to prevent the escape of sulphuretted hydrogen as this would give a result too high. This is accomplished by the use of dilute sulphuric acid instead of hydrochloric acid. If there is still an odor of sulphuretted hydrogen, a small quantity of powdered copper sulphate, ferric sulphate, or potassium dichromate is introduced into the bulb with the powdered rock. The carbon dioxide can be easily determined by this means.

After many years of trial, the writer commends this method on account of its simplicity and accuracy. It is a method that even the student with but small quantitative experience can use with success. His ability to secure good results at the outset increases his interest for the further prosecution of his quantitative work.

AN ANNOTATED LIST OF IOWA DISCOMYCETES.

FRED JAY SEAVER.

The Discomycetes include a large and much neglected group of fungi, variable in form and size and of wide distribution. During the last three seasons, a large number of local species have been added to those already reported, and in this paper an attempt has been made to bring together and list the species reported from the state. Those forms described and illustrated in the "Bulletin of Natural History" of the State University of Iowa (Vol. V, No. 4) are repeated here, and those which have not been described and figured will appear in a later edition of the same bulletin.

The list, as it appears here, is only a partial one, a large number of species having been collected which are still unidentified and new ones continually being added. It is hoped to extend this work and make it as complete as possible and any aid from those interested in the way of material will be gratefully received.

A brief note accompanies each species emphasizing some of the prominent characters, special attention being given to habitat and distribution. The name of the collector accompanies each species except where the collection was made by the author.

In preparing this list I am indebted to Profs. T. H. Macbride and B. Shimek for the use of numerous collections in the university herbarium and to Prof. L. H. Pammel, of Ames, for the use of the Holway collection which contained a number of species not collected at Iowa City and several exsiccati of much value.

HELVELLINEÆ.

FAMILY—GEOGLOSSACEÆ.

1. *Spathularia clavata* (Schaeff.) Sacc.

This species is known to but one locality in the north-east part of the state where it is found on the ground in pine woods among decaying needles. Collected by B. Shimek and E. W. D. Holway.

2. *Leotia stipitata* (Bosc.) Schroeter.

Pileus dark æruginous green; stem yellowish. On naked soil in woods. Turkey creek, autumn, 1902. Not uncommon.

3. *Leotia lubrica* (Scop.) Pers.

Pileus golden yellow becoming brownish or greenish; stem same color. In woods on soil among fallen leaves. Common in woods near Iowa City, during the autumn of 1904.

FAMILY—HELVELLACEÆ.

4. *Morchella esculenta* (Linn.) Pers.

Pileus globose or elongated. A common species in open woods. Various collections by T. H. Macbride and B. Shimek. Iowa City.

5. *Morchella conica* Pers.

Pileus conical; ribs longitudinally inclined. Closely related to the preceding. Not uncommon in open woods. Collected by T. H. Macbride and B. Shimek. Iowa City.

6. *Morchella delicosa* Fries.

Similar in form to the preceding but much smaller; stem stout; pits brownish inside; ribs light colored. Collected by S. C. Knupp in the spring of 1904. Iowa City.

7. *Morchella hybrida* (Sow.) Pers.

Stem large; pileus small and only partially united with the stem. Common in woods at the mouth of Turkey creek during the spring of 1897. Collected by B. Shimek.

8. *Helvella lacunosa* Afz.

Plants yellowish or brownish; pileus adnate with the stem. Various collections by T. H. Macbride and B.

Shimek. Iowa City; Winneshiek county, B. Shimek. Not uncommon in woods.

9. *Helvella crispa* (Scop.) Fries.

Plants snow-white; pileus generally free. Rather common on the ground in woods among fallen leaves during the autumn of 1904. Iowa City.

10. *Helvella elastica* Bull.

Stem slender and even. Not uncommon on soil in woods during the summer and autumn. Various collections. Iowa City;—Winneshiek county, B. Shimek.

11. *Helvella macropus* (Pers.) Karst.

Stem slender and generally even; pileus cup-shaped. Sometimes similar to preceding. Rather common on naked soil in woods. Iowa City.

12. *Gyromitra esculenta* Fries.

Pileus large undulated, brownish; stem short. Plants collected by T. H. Macbride. Iowa City. Rare.

FAMILY—RHIZINACEÆ.

13. *Sphærosoma echinulatum* Seaver.

Journal of Mycology 11, pp. 2-5. On damp clay soil. Common during the summer of 1904 in a ravine one mile north of Iowa City. A rare genus.

PEZIZINEÆ.

FAMILY—PYRONEMACEÆ.

14. *Pyronema omphalodes* (Bull.) Fckl.

Plants crowded, forming reddish or salmon-colored masses from one to two inches in diameter in damp places on charcoal and ashes where wood has been recently burned. Very common in wet weather on burnt places. Iowa City. Summer and autumn, 1904.

15. *Pyronema aurantio-rubrum* (Fckl.) Sacc.

Similar to preceding but distinguished by smaller sporidia. Collected on charcoal. Autumn, 1903. Iowa City.

16. *Pyronema melalomum* (Fries) Fckl.

Cups nearly plane, dingy red, 3 to 5 mm. in diameter. Very common on burnt places. Summer and autumn. Various collections, 1903-4. Iowa City.

FAMILY—PEZIZACEÆ.

17. *Sphærospora confusa* (Cooke) Sacc.

Plants nearly plane, brown, clothed with hairs; sporidia globose. Very common on a sandy bank in the woods one mile north of Iowa City. This species has been collected during the last three seasons in one locality where it occurs on naked soil or among moss plants. It is limited to a very small area and has not been collected in any other locality near Iowa City. 1902-4.

18. *Lachnea hemispherica* (Wigg.) Gill.

Cups hemispherical, .5 to 1 inch in diameter, white inside, externally clothed with brown hairs. Common on naked soil in woods. Various collections. Iowa City 1902-4;—Decorah, Iowa, July 15, 1882, E. W. D. Holway.

19. *Lachnea scutellata* (Linn.) Sacc.

Cups nearly plane, scarlet, .2 to .5 inches in diameter. Very common on decaying wood in moist places, often among moss plants. Various collections. Iowa City 1903-4.

20. *Lachnea setosa* (Nees) Sacc.

Similar to preceding but plants much smaller, lighter colored, and hairs much longer. Rather common on decaying wood. Often very numerous and gregarious. Various collections. Iowa City, 1902-4;—Winneshiek county, B. Shimek.

21. *Lachnea hirta* (Schum.) Sacc.

Plants brick-red, similar in size and general appearance to *Lachnea scutellata* (L.) S. but darker colored; spores rough instead of smooth as in the two preceding species. Rather common on the ground in wet places. Iowa City 1902-4;—Pocahontas county. Summer, 1903.

. *Lachnea melaloma* (A. & S.) Sacc.

Plants small, brownish-black. Found on burnt wood, d the surrounding soil. Iowa City. Autumn, 1903. Not mmon.

. *Lachnea abundans* Karst.

Plants small, 1 to 3 mm. in diameter, dull whitish, very uch crowded. Common in one locality during the itumn of 1904. On burnt wood and ashes. Iowa City.

. *Lachnea albo-spadicea* (Grev.) Sacc.

Plants small whitish, hemispherical, becoming nearly ane. On the ground in shady places. Iowa City. Rare.

. *Lachnea aurantiopsis* (Ellis) Sacc.

Plants about 1 cm. in diameter, yellowish or orange. On ossy logs. Collected by E. W. D. Holway, Decorah, Iowa, ovember, 1882.

. *Peziza aurantia* Pers.

Cups large, 1 inch or more in diameter, bright orange-d. Collected in considerable numbers during the autumn 1903 in a grassy place at the base of an oak stump. Also shady woods. Iowa City;—Decorah, Iowa, October, 82, E. W. D. Holway. Not very common.

. *Peziza rutilans* Fries.

Plants small, 1 cm. in diameter or less, orange-red, ex-nally whitish. Rather common in woods among moss ints. These plants seem to be found always with the ne kind of moss (Atrichum ?). Various collections, Iowa y, 1902-4.

Peziza vesiculosa Bull.

The specimen described in "The Discomycetes of East-n Iowa" I, p. 39 (reprint) as *Peziza cerea* Sow. is probably *ziza vesiculosa* Bull. From the description there seems be little distinction between the two species. The cups e large and often irregular in form and the flesh very ittle. This species has been found to be very common strawy manure and soil fertilized with such material. rious collections 1902-4. Iowa City;—Decorah, Iowa, ne, 1883, E. W. D. Holway.

29. *Peziza repanda* Wahl.

Collected by E. W. D. Holway at Decorah, Iowa, October, 1882. On old logs.

30. *Peziza badia* Pers.

Plants brown, about one inch in diameter. On naked soil in shady places, moist banks, etc. Iowa City. Summer and autumn, 1902-4. Not uncommon.

31. *Peziza brunneo-atra* Desm.

Plants very dark brown. Distinguished from the preceding by the plane disc-shaped receptacle. On the ground in shady places. Summer. Iowa City, 1904. Rare.

32. *Detonia trachycarpa* (Curr.) Sacc.

Plants large, nearly plane, dark brown. Distinguished from the genus Peziza by the globose spores. Plants were abundant during the autumn of 1904 on burnt places. This species and *Lachnea abundans* K. were found in the same locality, a piece of woods in which a large number of trees (*Populus tremuloides*) had been cut and the brush burned at various places a short distance apart. Both of these species were found in abundance on such places.

33. *Humaria Muralis* Quel.

Plants very small, 2 to 3 mm. in diameter, orange-red. Not uncommon in shady places, often on mossy banks by the roadsides. Autumn, 1904. Iowa City.

34. *Humaria tetraspora* (Fckl.) Sacc.

In external appearance resembling the preceding, but distinguished by the 4-spored asci. In damp mossy places. Autumn, 1903-4. Iowa City.

35. *Humaria humosa* (Fr.) Sacc.

Plants small, 2 to 5 mm. in diameter, orange-red. Common in moist places on naked soil and among moss. Autumn, 1903-4. Iowa City.

36. *Humaria leucoloma* (Hedw.) Fries.

Plants orange-red, very small, 1 to 2 mm. in diameter. Among moss in woods. Autumn, 1904. Rather common.

37. *Humaria granulata* (Bull.) Sacc.

Collected at Decorah, Iowa, on cow dung, 1885, E. W. D. Holway.

38. *Barlœa crec'hqueraultii* (Crouan) Sacc.

Plants very small, orange-yellow. Sporidia globose, echinulate. Numerous on clay soil in ravine. Summer, 1904. Iowa City.

39. *Barlœa cinnabarina* (Fckl.) Sacc.

Plants small, orange-red, at maturity, convex. Sporidia delicately reticulated. Rather common in shady places among moss. Summer, 1904. Iowa City.

40. *Barlœa amethystina* (Quel.) Sacc.

Plants very small, purplish, with a delicate light colored margin; sporidia verrucose. In woods among moss. Summer, 1904. Iowa City. Not uncommon.

41. *Geopyxis nebulosa* (Cooke.) Sacc.

Cups about 1 cm. in diameter, brown, stipitate. On rotten wood. Autumn,. 1903. Iowa City;—Decorah, Iowa, August 13, 1882, E. W. D. Holway. Not very common.

42. *Macropodia pubida* (B. & C.) Sacc.

Peziza pubida **Berkeley and Curtis, Grev. III, p. 153-4.**

Macropodia pubida **(B. & C.) Saccardo, Sylloge Fung. VIII, p. 159.**

Peziza Morgani **(Massee), Morgan, Jour. of Myc. 8, No. 64, p. 190.**

Exsiccati—Ellis N. A. Fungi, No. 1269; Rabenhorst-Winter, Fungi Europæi, No. 3275; *Peziza morgani*, Morgan's collection; *Peziza pubida*, Holway collection.

In "The Discomycetes of Eastern Iowa" I, p. 43 (reprint), it was suggested that *Peziza morgani* Massee might be identical with *Macropodia pubida* (B. & C.) Sacc. I have since been permitted by the kindness of Mr. Morgan to examine a portion of the type specimen of *Peziza morgani* and I find that this specimen is identical with *Peziza pubida* B. & C. of Ellis N. A. Fung., No. 1269 and also with the material described in this paper and in "The Discomycetes of Eastern Iowa" as *Macropodia pubida* (B. & C.) Sacc.

The specimen in " Rabenhorst-Winter Fungi Europea " No. 3275 is different. The plants are dark brown, only slightly granular on the outside (not velvety as described by Berkeley and Curtis for this species) and contain spores which are elliptical, rough, and only 15 by 8 microns, while in Berkeley's specimen the spores are described as fusiform and from 25 to 37 microns long.

Peziza morgani Massee then is identical with No. 1269 of Ellis N. A. Fungi and both conform to the original description of *Peziza pubida* Berkeley and Curtis as given in Grevillea, III, pp. 153-4. From the descriptions and material examined there seems to be no doubt that *Peziza morgani* Massee is *Peziza pubida* Berkeley and Curtis.

Peziza (_Sarcoscyphæ_) _pubida_ B. & C.—Grevillea, III, pp. 153-4.—Cupulis congestis hemisphericis, margine inflexo extus stipiteque brevi velutinis; paraphysibus brunneis; sporidiis fusiformibus granulatis.

On the ground. Alabama, Peters. No. 6075. Cups three-fourths inch across, crowded, hemispherical, with an inflexed margin, velvety externally as well as the short stem; paraphyses brown; sporidia spindle-shaped, granulated, .001-.0015 long. Mycelium densely betulose. Closely related to the last (_P. semitosta_).

This species is not uncommon on naked soil in woods. The plants are easily distinguished from the characters given by Berkeley in his description quoted above. The cups are hemispherical and with a short stem-like base, the stem and outside of the cup being clothed with short, brown hairs, giving it a velvety appearance. The hymenium is dark colored, when dry almost black. One of the most prominent characters of the species is the large, fusiform spores which at maturity are delicately warted. In woods near Turkey creek, July 30, 1903;—Decorah, Iowa, August 25, 1882, E. W. D. Holway.

43. *Acetabula vulgaris* (Fr.) Fckl.

Cups 1 inch or more in diameter, stipitate; stem and outside of cup costate. Collected by T. H. Macbride in woods near Iowa City, May, 1890;—Decorah, Iowa, July, 1885, E. W. D. Holway. Rare.

44. *Acetabula sulcata* (Pers.) Fckl.

Cups large, yellowish or brownish, with a short, thick, costate stem. On naked soil in woods. Unionville, Iowa. Spring, 1904. Rare.

45. *Galactinia succosa* (Berk.) Sacc.

Cups rather large, .5 to 1 inch in diameter, or more; hymenium brownish; externally yellowish; juice thick, golden yellow. Rather common on naked soil in woods. Various collections, 1902-4. Iowa City.

46. *Otidea leporina* (Batsch.) Fckl.

Cups large, brownish, split on one side nearly to the base. In woods, Winneshiek county, B. Shimek.

47. *Otidea ochracea* (Fr.) Sacc.

Cups much smaller than preceding, yellowish. In woods, Winneshiek county, B. Shimek.

FAMILY—ASCOBOLACEÆ.

48. *Lasiobolus equinus* (Mull.) Karst.

Plants very small, orange-red, clothed externally with nonseptate hairs. On cow dung, spring, summer and autumn. Various collections, 1903-5, Iowa City;—Decorah, Iowa, May, 1886, E. W. D. Holway. Very common.

49. *Lasiobolus raripilus* (Phill.) Sacc.

Plants very much crowded, forming a yellowish mass. On cow dung in a ravine. Autumn, 1903, Iowa City. Rare.

50. *Ascophanus microsporus* (B. & Br.) P.

Very minute, yellowish when fresh, black when dry. On cow dung. Spring and summer. Iowa City;—Decorah, Iowa, May, 1886, E. W. D. Holway. Very common.

51. *Ascophanus cinereus* (Crouan) Boud.

Grown on horse dung in culture. Iowa City. Rare.

52. *Ascophanus testaceus* (Moug.) Phill.

Plants small, orange-red. On old cloth, paper, etc. On old rag carpet. Pocahontas, Iowa. Summer, 1903. Rare.

53. *Ascophanus granuliformis* (Cr.) Boud.

On cow dung. Decorah, Iowa, May 25, 1886, E. W. D. Holway.

54. *Ascophanus carneus* (Pers.) Sacc.

On cow dung. Decorah, Iowa, April 25, 1886, E. W. D. Holway.

55. *Ryparobius pelletieri* (Cr.) Sacc.

Plants very small, white, nearly cylindrical; asci 32-spored. On cow dung in moist places. Various collections, Iowa City, 1902-4. Not uncommon.

56. *Ryparobius sexdecimsporus* (Cr.) Sacc.

Plants very small, whitish; asci 16-spored. On cow dung. Various collections, 1903-4. Iowa City. Not uncommon.

57. *Ryparobius crustaceus* (Fckl.) Rehm.

Plants similar in external appearance to preceding but asci 64-spored. On cow dung. Iowa City. Not uncommon.

58. *Ryparobius pachyascus* Rehm.

Very minute; asci large, many-spored. On cow dung. Not common.

59. *Saccobolus kerverni* (Crouan) Boud.

Plants small, golden yellow when fresh, black when dry. On cow dung. Various collections, Iowa City, 1903-4;—Decorah, Iowa, May, 1886, E. W. D. Holway. Common in moist places.

60. *Ascobolus furfuraceus* Pers.

Plants light yellowish, as large as 5 mm. in diameter. On cow dung. Iowa City, 1903-5;—Decorah, Iowa, April 25, 1886, E. W. D. Holway. Spring, summer and autumn. Very common.

61. *Ascobolus immersus* Pers.

Plants very small; asci and sporidia very large. On cow dung, spring and summer. Various collections, Iowa City 1903-4; March, 1905. Not uncommon.

62. *Ascobolus glaber* Pers.

Plants very small; sporidia much smaller than in preceding. Grown in culture. Iowa City. Rare.

63. *Ascobolus atro-fuscus* Phil. & Plow.

Plants as large as 6 mm. in diameter, brownish when fresh, when dry hymenium almost black. One collection was made in October, 1903. During the summer of 1904 this species was found to be very common on burnt places. It is easily distinguished by its habitat, its brownish color, and the purple, verrucose sporidia.

64. *Ascobolus viridis* Curr.

Plants rather small, about 3 mm. in diameter, yellowish brown or greenish. The sporidia are covered with net-like reticulations. On mud flats near the Iowa river. Summer

and autumn, 1904. Iowa City. This species has been found to be very common on rather hard, damp, clay soil.

65. *Ascobolus brunneus* Cooke.

Collected on horse dung. Autumn, 1904. Iowa City. Not common.

FAMILY—HELOTIACEÆ.

66. *Sarcoscypha coccinea* (Jacq.) Cke.

Cups large, generally stipitate; hymenium scarlet. Various collections, 1902-05. Iowa City;—Decorah, Iowa, March, 1879, E. W. D. Holway;—FortDodge, Iowa, 1904, B. Shimek. Very common on half buried sticks in the woods. Late autumn and early spring.

67. *Sarcoscypha occidentalis* (Schw.) Cke.

Cups much smaller than preceding; stem often very long; hymenium scarlet. On decaying sticks in woods. Spring and summer. Various collections, 1903-04. Iowa City;—Decorah, Iowa, August, 1882, E. W. D. Holway. Rather common.

68. *Sarcoscypha floccosa* (Schw.) Cke.

Cups scarlet inside, clothed with long, white, septate hairs externally. On decaying sticks, spring and summer. Various collections, 1903-04. Iowa City;—Decorah, Iowa, August, 1882, E. W. D. Holway. Rather common in woods.

69. *Chlorosplenium æruginosum* (Nyl.) Karst.

Plants small, stipitate, dark, æruginous green. On wood (oak). Distinguished by the green color of the plants and the wood from which they grow. Various collections. Iowa city. T. H. Macbride and B. Shimek;—Decorah, Iowa, August, 1882, E. W. D. Holway.

70. *Chlorosplenium versiforme* (Pers.) Karst.

Plants irregular in form, greenish. On wood. Decorah, Iowa, August, 1882, E. W. D. Holway.

71. *Dasyscypha nivea* (Hedw.) Sacc.

Plants minute, stipitate, clothed externally with a dense covering of white hairs. On decaying wood (oak). Iowa City, 1904. Common.

72. *Dasyscypha pygmæa* (Fr.) Sacc.

Plants small, yellowish, with a long stem; stem often branched. On half buried sticks and roots in damp place. Summer, 1904. Not common.

73. *Trichopeziza tiliæ* (Peck) Sacc.

Plants small, white, clothed externally with a dense covering of white hairs. Abundant on decaying branches of *Tilia americana*. Unionville, Iowa, May, 1904.

74. *Trichopeziza comata* (Schw.) Sacc.

Plants very small, white, similar to preceding in general appearance but smaller. On decaying oak leaves in wet places. Summer, 1904. Iowa City. Not uncommon.

75. *Phialea fructigena* (Bull.) Gill.

Plants small, yellowish, stipitate or nearly sessile. On acorns and hickory nut husks in wet places in woods. Summer and autumn, 1904. Iowa City. Not uncommon, sometimes abundant.

76. *Ciboria pseudotuberosa* Rehm.

Plants stipitate about 1 cm. in diameter. On acorns. Summer, 1904. Iowa City;—Decorah, Iowa, September, 1882, E. W. D. Holway. Not common.

77. *Helotium citrinum* (Hedw.) Fr.

Plants rather large, .5 to 1 cm. in diameter, stipitate or nearly sessile, lemon-yellow. On rotten wood, Various collections. Iowa City, 1902-5. Very common.

78. *Helotium aciculare* (Bull.) Pers.

Plants small, yellowish, shortly stipitate. On decaying leaves of *Populus tremuloides*. Autumn, 1904. Iowa City. Not very common.

79. *Helotium pallescens* (Pers.) Fr.

Plants very small, light yellow. On much decayed wood. Summer, 1904. Iowa City. Not common.

80. *Coryne sarcoides* (Jacq.) Tul.

Plants rather large, irregular in form, purple or reddish, often cæspitose. On rotten wood in moist places. Various collections, 1902-4. Iowa City. Rather common.

FAMILY—MOLLISIACEÆ.

81. *Mollisia dehnii* (Rabenh.) Karst.

Plants small, parasitic on leaves and stems of *Potentilla norvegica*. Pocahontas, Iowa, summer, 1903;—Iowa City, summer, 1904. Not uncommon.

82. *Mollisia polygoni* (Lasch.) Gill.

Plants very small. On decaying stems of Polygonum. Spring and summer. Iowa City. Common.

83. *Mollisia cinerea* (Batsch.) Karst.

Plants rather small, grayish, sessile, margin often irregularly folded. This species seems to be very common and widely distributed. It occurs on various kinds of decaying wood. Various collections, 1904-5. Iowa City;—Decorah, Iowa, June 26, 1882, E. W. D. Holway.

84. *Niptera saliceti* (Rehm.) Sacc.

Plants minute, light colored. This genus is distinguished from the preceding by the septate sporidia. This species was collected on wood which was so much decayed that it was impossible to determine the kind of wood. Summer, 1904. Iowa City. Not common.

85. *Orbilia chrysocoma* (Bull.) Sacc.

Plants very small, sessile, yellowish. On rotten wood. Iowa City;—Decorah, Iowa, August, 1882, E. W. D. Holway. This species is very common in woods.

86. *Orbilia vinosa* (A. & S.) Karst.

Plants small, similar to preceding but red instead of yellow. On rotten wood. Iowa City, 1904. Common.

FAMILY—PATELLARIACEÆ.

87. *Karschia lignyota* (Fr.) Sacc.

Plants small, black; hymenium nearly plane; sporidia 1-septate, brownish. On decorticated wood. Autumn, 1902 Iowa City. Not common.

88. *Patellaria melaxantha* Fries.

Plants very small, yellowish, gregarious, often confluent; sporidia several septate. On wood. Iowa City. Rare.

89. *Patellaria clavispora* (Peck) Sacc.

Plants very small, black, when dry hysteriofc elongated, when wet becoming more or less expan older specimens often circular in outline; sporidia cla\ 3 to 4-septate, brownish. This species has been foun be very common on decorticated willow and often on bark. The plants, especially when young, resemble t of the genus Hysterium but when mature resemble r closely those of the genus Patellaria. Various collecti 1902-5. Iowa City. Very common on willow.

90. *Lecanidion atratum* (Hedw.) Rabenh.

Plants small, black; hymenium nearly plane; spoı hyaline, 7 to 10-septate; paraphyses bluish. On dec cated wood. Autumn, 1904. Iowa City. Rather comr

91. *Lecanidion tetraspora* M. & M.

Patellaria tetraspora, Journal of Mycology 8, p. Very closely related to the preceding but asci 4-spored more cylindrical. Plants very small, black in n gregarious. On decorticated wood (ash ?). Autumn, 1 Iowa City. Rather common.

92. *Blytridium fenestratum* (C. & P.) Sacc.

Plants small, black, circular in outline; hymen almost plane; sporidia muriform. On poplar branc Decorah, Iowa, August, 1882, E. W. D. Holway.

FAMILY—CENANGIACEÆ.

93. *Cenangium populueum* (Pers.) Rehm.

Plants breaking through the epidermis, cæspitose, bro ish, 5 mm. to 2 cm. in diameter. On dead branche *Populus tremuloides* and *P. grandidentata*. Howard cou B. Shimek;—Iowa City, April 13, 1905. Very abun(and common.

94. *Cenangium rubiginosum* (Fr.) Sacc.

On dead limbs of *Carpinus americana*. Decorah, I(E. W. D. Holway.

95. *Dermatea cerasi* (Pers.) Fr.

Plants small, light colored externally; hymenium d On rotten wood. Iowa City. Rare.

96. *Bulgaria inquinans* (Pers.) Fr.

Plants cæspitose, substipitate, black or brownish-black. Various collections, 1902-4. Iowa City. Very common on bark of oak.

97. *Bulgaria rufa* Schw.

Cups large, cæspitose, externally dark brownish; hymenium light colored, slightly reddish. On dead limbs. Iowa City. Rather common.

98. *Holwaya ophiobolus* (Ellis) Sacc.

Similar in external appearance to *Bulgaria inquinans* but smaller; sporidia very long and slender and multiseptate. On wood. Decorah, Iowa, E. W. D. Holway.

99. *Urnula craterium* (Schw.) Fr.

Plants very large, long stipitate, urn-shaped, blackish. On half buried branches. Various collections, 1902-5. Iowa City. Very common and abundant.

HYSTERINEÆ.

This order includes a large number of plants which are intermediate between the *Discomycetes* and the *Pyrenomycetes*. By some authors they are included with the former and by others with the latter group. The plants of this group are elliptical or elongated in form, generally black in color and rather hard. They open at maturity with a long slit-like aperture, the lips sometimes spreading apart and sometimes remaining tightly closed. A few of the forms collected are included here.

FAMILY—HYSTERIACEÆ.

100. *Glonium stellatum* Muhl.

Perithecia stellately arranged, very abundant; sporidia long, hyaline, 1-septate. On rotten wood. Collected by T. H. Macbride. Iowa City.

101. *Hysterium pulicare* Pers.

Perithecia gregarious, small; sporidia 3-septate brownish. On bark of different trees. Collected by T. H. Macbride. Iowa City, Rather common.

102. *Hysterographium mori* (Schw.) Ellis.

Perithecia gregarious or crowded; sporidia 3 to 5-septate and muriform, constricted in the middle. On decorticated wood (oak and sumach). Iowa City. Very common.

103. *Hysterographium fraxini* (Pers.) Ellis.

Perithecia scattered or gregarious; sporidia large, muriform, and 7 to 9-septate. On dead limbs of ash. Decorah, Iowa, E. W. D. Holway.

104. *Hysterographium cinerascens* Schw.

Perithecia gregarious or crowded; sporidia 6 to 8-septate, muriform and constricted in the middle. On decorticated wood (butternut). Iowa City, 1904.

This species seems to conform to the description of *H. cinerascens* and is included under this name here. The plants are quite abundant on old butternut wood.

THE BIOLOGY OF THE BACILLUS VIOLACEUS LAURENTIUS OR PSEUDOMONAS JANTHINA.

BY GRACE ROODDE RUEDA.

The first mention of pigment producing growth is of great antiquity. It aroused the suspicion of the ancients, worked on the religious zeal of the people of the Middle Ages, and today solicits the study and investigation of modern scientists. In the light of our present cultural means of study the chromogenic group of bacteria is especially interesting. The products can be easily watched and as easily segregated. Each organism can be classed together under color and can thus be definitely recognized. The *B. prodigiosus* is such an organism. It responds fully to laboratory methods. It has been thoroughly studied and is one of the first specimens to be put into the hands of beginning students. Among the yellow bacteria that have been carefully investigated may be mentioned *Sarcina aurantiaca* and *S. lutea*.

In early days religious teachers, such as the Egyptian priests and the Zoroastrians, forbade their disciples many kinds of food, among which were white cooked beans. Pythagoras no doubt took his antipathy for beans from these sects. However, he said that beans were not wholesome, because if placed in the moonlight they would change to blood. Once when the besieging army of Alexander the Great lay before the city of Tyre their bread was found to be bloody red. This created a great consternation among the soldiers. The priests, when called upon to explain the mystery, said that it meant that a bloody fate awaited the people inside the city walls because the red color was found on the inside of the loaf.

The miracles of the "Bloody Host" of the first part of the Christian Era are familiar to every one. The sacramental bread was rich in starch and poor in acid so it gave a good medium for the development of the *B. prodigiosus* germs. The priests of the middle ages knew how to make the most of such a striking phenomenon. In recent times, during the siege of Paris, large quantities of bread became red through the action and growth of *B. prodigiosus*.

Blue milk, green and yellow milk are all facts that have been noted by our forefathers but today scientists have proved such color changes to be due to various chromogenic bacteria. A number of blue chromogenes occur in water, milk and liquids. Chester names several. Other blue organisms have been described by Hueppe, Sternberg, etc., yet thus far only ten species have been found in our Iowa flora. *B. violaceus laurentius* and *Micrococcus cyanogenus* are some of them. The latter Doctor Pammel and Mr. Combs have described as follows:

Source.—During the latter part of May, 1894, a foreign blue color was observed in an old milk culture of an organism obtained from cheese; later the same was found in an old milk culture of *B. aromaticus*. A transfer from the first milk tube was made to another tube of sterilized milk, the typical color appearing in three or four days. The organism was separated by pouring plates of agar.

Morphology.—A small micrococcus occurring singly or in groups; motility not determined. An ærobic liquefying micrococcus.

Agar.—Nearly colorless, with a slight tinge of blue, producing an irregular film on the surface. Grows at the temperature of the room.

Gelatin.—A creamy white layer not spreading on surface, soon liquefying, forming a funnel shaped area, later the medium was liquefied with a creamy white sediment in the bottom of the tube.

Milk.—Sterilized milk inoculated produces in three days a slight blue layer on surface, which increases in intensity, becoming quite blue for one third of an inch on

the seventh day. On the eighth day it appeared rather muddy; it coagulated milk with a blue liquid on top. The curd was dissolved slowly. In twenty-five days the process was completed excepting a small portion in bottom of the flask.

Dunham's peptone solution.—No color produced. The medium became cloudy, which was by no means characteristic. It failed to grow in Dunham's rosalic acid solution.

B. pyocyaneus is another familiar organism which produces blue color. Dr. M. Nicolle and Dr. Zia Bey record observations, made from four samples, relative to the pigmentary functions of this organism. On one medium the composition of which is not given, the pigment was greenish and non-fluorescent, on the other four media green and fluorescent. The authors also found that the presence of phosphates in the medium, while favoring the formation of fluorescent green pigment was not an indispensable condition thereof. While the greenish pigment and the rusty-brown pigment (resulting from the oxidation of the fluorescent green) passed readily through the Chamberland filter, the fluorescent green pigment was entirely held back.

This slightly disagrees with Herr K. Wolf, who says: "The green pigment of fluorescing bacteria occurs only when the conditions of nutrition are extremely favorable to bacteria. The production of pigment is of necessity associated with three factors, phosphoric acid salts, easily decomposable ammonia compounds, and free oxygen. If one of these factors be absent or insufficient, pigment does not appear. During the ærobic growth of fluorescent bacteria, oxygen is copiously absorbed and carbonic acid gas is given off. Under similar conditions fluorescing bacteria produce a very considerable quantity of ammonia."

Along the same lines Doctor Keferstein describes a coccus which imparts a reddish hue to milk. "The color first appears five or six days after inoculation, and attains its maximum degree in about two weeks. The formation of

pigment is dependent on the presence of air. On gelatin the colonies are small and rose-colored, afterwards deepening in hue; the medium is not liquefied."

The black spots so often found on Parmesan cheese, and that so often give forth the odor of garlic, are caused by bacteria. Herr G. Marpmann indicates that these black spots are due to the presence of ferrophilous bacteria that form sulphides. The pigment is produced only when the media contains iron. The presence of iron and sulphides is easily demonstrable by the ordinary chemical tests. The garlicky odor is common to decomposing organic matter which contains phosphates, and is due to the presence of phosphuretted hydrogen. The presence of this compound can be demonstrated, and distinguished from sulphuretted hydrogen by the reaction to test-papers moistened with silver nitrate and lead acetate solutions. The former is stained by the phosphuretted hydrogen, the latter by the sulphur compound."

The *B. violaceus* produces purple color that is quite as characteristic as the red, blue and green pigments, but in standard books on bacteriology little seems to have been written about it. However, about 1895 Prof. H. M. Ward describes a violet bacillus which was derived from the Thames. "Morphologically it presents itself in the form of rodlets or filaments. These rodlets may be so short as to be almost cocci. It may be quiescent or actively motile, and in old cultures involution forms are found. Spore formation was not observed. It is ærobic, liquefies gelatin, grows slowly, its optimum temperature is 20°, it is easily killed by direct sunlight, and is not pathogenic to animals. It was grown on gelatin, agar, potato, or broth and milk. The growth at first white, develops later a violet pigment which is insoluble in water, but very soluble in alcohol. It is very stable, except in sunlight, is turned bluish-green on adding caustic alkali, the color nearly returning by excess of acid." Many of the North American chromogenic bacteria have been treated by other writers, such as Sternberg, and Jordan. Miss Hef-

feran has an article which is the result of a comparative and experimental study of bacilli producing red pigment. Hueppe has done a great deal in identifying species. He was the first to isolate *B. violaceus laurentius* from the Lawrence sewage experiment station in 1890.

Chester in his classification recognizes:

B. violaceus laurentius,
B. violaceus lutetiensis,
B. violaceus berolinensis,
B. violaceus or *Ps. janthina*,
B. violaceus sacchari, or *B. æris*, a violet colored pigment noted in old milk cultures and whose habitat is the air.

The organism that has been studied in connection with this paper Doctor Pammel isolated in March, 1904, from a well near the campus. It was identified as *B. violaceus*. A month later one of the students isolated it from a sample taken from the creek running through the college park and receiving sewage from adjoining farms. At the same time I was making a study of the biological conditions of the Iowa State College sewage disposal plant and isolated a violet organism from the effluent. At that time a cultural study was made and the growth was noted as follows:

Source.—Brought to the laboratory from a well near the campus. Found in effluent of sewer. Found also in creek.

Morphology.—Short, slight bacilli with rounded ends. Often occurs in pairs, sometimes in chains of four or five. No spore formation observed.

Habitat.—Water.

Motility.—Actively motile.

Color.—Produces violet color on top of slant and stab cultures. No color along stab; hence needs oxygen for production of pigment.

Agar Stab.—Vigorous growth along stab. A white spot appears on top which turns violet in color. The colony spreads in a thin irregular expansion. It covers the top of the medium and the color changes to black or dark purple.

This description agreed with that given by Chester and we conclude that the organism is a variety of the *B. violaceus*.

In order to test for gas production a fermentation tube which contained bouillon was inoculated in May, 1904. This was kept during the summer. In September a thick growth in the bottom of the neck of the tube and a tough leathery layer was on top of the liquid. It was, without doubt, a pure culture. Inoculations were made on the usual cultural media. Growth in many cases appeared, but no color could be obtained on agar, gelatine, potato, or blood serum. To test for involution forms, it was grown in a standard asparagin solution. They were easily found and a slight color first appeared on the edge of the medium. It later was dissolved. The organism had been grown for a long time in sugar bouillon and evidently it had lost its power to make pigment. However, it must be noted that the media had been made for regular laboratory exercises and had been prepared with special pains to keep it free from nitrogen. The results from these last inoculations were as follows:

Agar Stab.—No growth along stab but a white glistening growth on top. No color.

Agar Slant.—Abundant growth of glistening white viscid colonies. No color.

Potato.—Granular shiny colonies. Brownish.

In order to get a solid medium of known composition a paste of rice flour was made and another of arrowroot starch. These were partially cooked and then put into tubes and sterilized for twenty minutes in an autoclave. The tubes were then inoculated from the sugar bouillon culture that had been growing all summer. The results were as follows:

Arrowroot.—In twelve hours a spot of purple color could be seen. At the end of a week it had penetrated through the medium. At the end of a month the paste was colored throughout and was half liquefied. Here then was the proper nutrient medium. The arrowroot is pure starch and the *B. violaceus* var. must produce an enzyme that reduces the starch.

Rice Starch.—At the end of three days color gathered ound the edge. Starch was not liquefied but seemed to y up. Color remained about constant.

When grown in milk a curd was first produced. The lor gathered on the top and later a greenish-blue lor was disseminated through the liquid. In one week's ne the curd was dissolved and a pellicle of heavy growth ıs in the bottom of the tube.

In ordinary bouillion a growth could be seen, the bouil-n was cloudy but no color came. However when one-nth of one per cent solution of potassium nitrate was ldéd to agar slant and stab cultures, which being duly oculated, produced growth in about the same time as did .e nitrogen-free agar. But at the end of one day color, hich spread rapidly over the entire surface, could be seen.

From these observations it may be noted that the organ-m grows on top of nitrogen-free agar but without color; ıd that oxygen is necessary for its growth. Also that ıe organism produces color and grows on top of agar that ıntains nitrogen. Therefore nitrogen seems necessary r the development of pigment.

As a result of these observations the conclusion is that e production of color is dependent on environment; and at this chromogenic organism grows rapidly in the proper edium.

Although *B. violaceus* var. does not produce color in nitro-ın-free bouillon nor agar without nitrogen, one should ıt draw the conclusion that all chromogenic organisms quire nitrogen. For the large amount of color in arrow-ot starch and in sugar bouillon after standing five onths should receive attention.

To further determine the conditions in which it would ow in non-proteid medium of known composition the llowing media were made:

Solution.	Per cents.				
	A	B	C	D	E
Asparagin	0.2	0.2	0.2	0.1	1.0
$MgSO_4$	.1	.....	.2	.1	.1
K_2HPO_4	.1	.1	.....	.1	.1
Glycerin	.....	.....	.....	....	2.0

Solution B. had a tinge of color and quite a growth.
Solution C. had color, but little growth.
Solution D. had very little color, made little growth.
Solution E. had good growth but no color.

In solution B the magnesium sulphate was eliminated to see if it would make a change in the amount of pigment. A faint suspicion of color and same growth as in solution A was noted. In solution C potassium phosphate was eliminated with the result that the color was about like that in A, but the growth was poor. Then to see if it could be the organic matter that was necessary, the asparagin was reduced to one tenth of one per cent with the result of but slight growth and no color. In solution E, glycerin was added and the result was a good growth but no color.

Kuntze and Nuesske hold that magnesium sulphate is necessary for color, and potassium sulphate for bacterial growth. By the above experiments the deduction would seem to hold good for *B. vioalceus.*

Three other solutions which contained each one-tenth of one per cent of the three sugars were prepared. Growth and color seemed to be stopped in the solutions that contained dextrose and saccharose. It must be remembered, however, that the organism had been kept for five months in a saccharose bouillon solution.

In the lactose solution the growth was vigorous but without color. The other sugars semed to be sufficient in amount to inhibit all growth if not to kill the organism outright. Dr. F. E. Hellstrom experimented on the effect of small quantities of glucose on the vitality of bacteria and found "that the addition of glucose in the proportion of 0.1 per cent for cholera, 0.2 per cent for typhoid, and 0.3 per cent for other kinds of bacteria to simple

bouillon (2 liters of water to 1 kg. meat), without peptone, and with a neutral or faintly acid initial reaction, exerts within a few days a deleterious action, owing to the medium turning acid. When the medium contains a still smaller quantity of nutritive material, a less amount of glucose suffices to bring about a fatal effect; and conversely, when the amount of nutritive substance is greater, a larger amount of glucose is required to exert a pernicious action. A small quantity of glucose in bouillon is favorable to the increase of essential ærobes, and thus the amount of glucose stands in direct relation to that of the nutritive material in the bouillon."

Koosowicz, the bacteriologist, cultivated *B. prodigiosus* in solution containing:

0.3 per cent solution of saccharose
.25 per cent solution of KH_2PO_4
.005 per cent solution of $Ca_3(PO_4)_2$
.25 per cent solution of $MgSO_4$
.25 per cent solution of $(NH_4)_2HPO_4$
.2 per cent solution of NH_4Cl

The organism produced a citrine yellow coloring material which diffused through the medium. The yellow coloring usually appears in the course of two or three weeks, transferring same to potato or meat bouillon gave red colonies. Red colonies were produced by *B. lacto-rubefaciens* and *M. agilis*. *B. xynantheum* also produces a reddish-brown color which is intensified in media containing $MgSO_4$.

Migula says that *B. prodigiosus* produces red color in acid medium. In neutral, it is colorless. Colorless colonies also occur from exposure to light. *B. kiliensis* produces on potato at first a brick red color, later red, and on neutral agar, yellow red. *B. cyanogenus* produces blue color only in acid medium. In alkaline medium a dirty gray fluorescence, on potatoes a yellow.

Thomas Milburn made an exhaustive study of the influence of grape sugar on *B. prodigiosus*. He made up various solutions, containing different per cents of glucose.

Medium with the Addition of Glucose		Reaction.	Color.
No. 1	Check......	Alkaline............	Orange-red.
No. 2	.1 per cent......	Neutral.................	Carmine to violet.
No. 3	1 per cent.....	Faintly acid.............	Red-violet, big growth.
No. 4	2 per cent.....	Faintly acid.............	Red-violet, big growth.
No. 5	3 per cent.....	Acid.....................	Violet with some white.
No. 6	4 per cent.....	Acid strongly............	White.
No. 7	5 per cent.....	Acid strongly............	White.
No. 8	6 per cent.....	Acid strongly............	White.
No. 9	7 per cent.....	Acid strongly............	No growth.

He made a study of *B. ruber balticus*, the so-called Kiel water bacillus. Schotellius by growing the organisms at higher temperatures obtained colorless colonies. But these varieties are inconstant and further cultures in nutrient media cause the organism to take on color. Migula refers to these as forms rather than varieties. Laurent made careful investigations and arrived at the following conclusions:

That *B. ruber balticus* on certain media produces acid material, and on others, alkaline.

That high temperature is unfavorable for production of color.

That colorless forms may be obtained through culture in direct sunlight on strongly acid and strongly alkaline media.

When grown on potato at 35° C. the violet color disappears. If the culture is allowed to stand for one day at 18° C. it becomes carmine red. At 35° C. it becomes violet upon addition of HCl. Saltz is sure that the violet color is intensified.

It follows from his results that in cultures kept at high temperatures the breathing powers of bacteria and the production of carbon dioxide is favored, and carbon dioxide favors production of violet pigment. According to Milburn the production of violet color is influenced through the action of the medium. When it is acid the violet color is produced, when alkaline an orange red color appears.

To show the effect of light on the chromogenisis of *B. violaceous*, six agar slants were inoculated. Then they were exposed to the direct rays of the sunlight:—

No. 1 exposed for 5 min.—A was kept as check.
No. 2 exposed for 15 min.—B was kept as check.
No. 3 exposed for 30 min.—C was kept as check.

At the end of forty-eight hours number 1 seemed slightly more vigorous than A. At the end of the same time number 2 had a much more vigorous growth than B, but at the end of three days was much less vigorous than the check. Number 3 at the end of forty-eight hours had no growth at all while C corresponded with the other checks A and B.

It seems from this experiment that a short exposure to sunlight does not affect the growth. That a fifteen minute exposure of a culture stimulates the growth temporarily. Gotschlich has remarked that brief exposure of a culture to injurious influences may react beneficially to a culture as a whole by cutting out the weaker organisms and leaving only the virulent ones; that is, that there may be a selective death-rate. Basing our explanation on the above principle, the first effect of the sunlight was the destruction of a number of the less resistant violet producing cells. This accounts for the fact that the five minute exposure was slightly more vigorous than the check, A. While in number 2 we must assume that after the weak organisms had been killed by the sunlight the actinic effect of a fifteen minute exposure was stimulating and promoted cell division. To get the benefit from such influence the organisms must be returned to normal conditions. The accelerating effect of such exposure does not seem to be an enduring one, because on examination at the end of three days number 2 seemed to be much retarded and development was permanently hindered. A longer exposure to sunlight killed the cells outright. It is in this way that the sun's rays prove to be such a good disinfectant for bacterial life.

With these facts gathered no further attempt was made to study the biology of the organism.

CONCLUSIONS.

Chromogenes have interested scientists and they form a basis of classification.

The organism was taken from water on the campus and proved to be *B. violaceous laurentius.*

Oxygen is essential to growth and the production of color.

It grows best in medium that contains nitrogen and in that medium grows rapidly. Its color characteristics depend on the environment, or medium used.

When grown in standard solutions its action strengthens the conclusion that potassium phosphate is necessary for bacterial growth and magnesium is nesessary for the production of color.

It grows well on arrowroot starch and produces an enzyme that reduces the starch.

It grows in lactose solution but the other sugars seem to inhibit its growth.

Long exposure to the sunlight is detrimental.

Short exposure may be beneficial in as much as it kills some of the weaker organisms and thus gives a full chance for the stronger ones to develop.

PLANTS NEW TO THE FLORA OF DECATUR COUNTY, IOWA.

BY J. P. ANDERSON.

In this paper it is the intention of the writer to enumerate only such species as have not before been reported from the above named county in any of the papers presented to this Academy. Duplications may occur but we have tried to avoid them. This list brings the total of the flowering plants reported from this one county up to about 628. Work done on other groups is not now in proper shape for presentation. Great care has been exercised in the determination of species and several species have been omitted from this list because of some doubt as to the accuracy of the determination. The nomenclature here used is that of Britton and Brown's Illustrated Flora.

SPARGANIACEÆ.

Sparganium eurycarpum Engelm. Broad-fruited Bur-reed. Occurs along the edges of a pond near Grand river.

NAIADACEÆ.

Potamogeton pusillus L. Small Pondweed. Abundant in some ponds east of Davis City. I have also found it near Lamoni. June 23, 1900.

Potamogeton lonchites Tuckerm. Long-fruited Pondweed. In a pond near the Weldon river. July 28, 1900.

ALISMACEÆ.

Sagittaria rigida Pursh. Sessile-fruiting Arrowhead. In ponds near the Grand River. July 24, 1899.

Sagittaria graminea Michx. Grass-leaved Sagittaria. In some railroad ponds near Davis City. August 13, 1903.

GRAMINEÆ.

Panicum proliferum Lam. Spreading Panicum. Roadside and wastes. Common. September 3, 1903.

Panicum depauperatum Muhl. Starved Panicum. Dry soil. Frequent. June 6, 1898.

Panicum leibergii Scribne. Leiberg's Panicum. June 6, 1898.

Zizania aquatica L. Wild Rice. In a swamp near the Grand river. July 24, 1899.

Phalaris arundinacea L. Reed Canary-grass. In wet soil. Frequent. July 6, 1898.

Alopecurus geniculatus L. Marsh Fox-tail. Wet or marshy soil. June 15, 1901.

Agrostis hyemalis (Walt.) B. S. P. Rough Hair-grass. June 9, 1898.

Melica mutica Walt. Narrow-leaved Melic Grass. Frequent in woods.

Eragrostis frankii Steud. Frank's Eragrostis. Grows on moist soil. August 18, 1898.

Eragrostis capillaris (L.) Nees. Capillary Eragrostis. Dry soil. September 3, 1898.

Eragrostis pectinacea (Michx.) Steud. Purple Eragrostis. Upland meadows. Frequent.

CYPERACEÆ.

Cyperus erythrorhizos Muhl. Red-rooted Cyperus. Wet, sandy soil. Frequent. July 29, 1897.

Eleocharis acicularis (L.) R. & S. Wet or swampy soil. 1903.

Carex lupulina Muhl. Hop Sedge. Wet soil. Moderately frequent. July 1, 1897.

Carex pubescens Muhl. Pubescent Sedge. Woods. June 6, 1898.

Carex stricta Lam. Tussock Sedge. Wet soil. May 23, 1898.

Carex davisii Schwein & Torr. Davis' Sedge. Moist woods. June 15, 1901.

Carex bicknellii Britton. Bicknell's Sedge. Dry soil. June 6, 1898.

Carex stipata Muhl. Awl-fruited Sedge. Wet soil. June 6, 1898.

Carex cephalophora Muhl. Oval-headed Sedge. Dry soil. June 6, 1898.

Carex asa-grayi Bailey. Gray's Sedge. Wet soil. Infrequent. June 6, 1898.

Carex cristatella Britton. Crested Sedge. Meadows. June 6, 1898.

Carex tetanica Schk. Wood's Sedge. Meadows. May 19, 1898.

ARACEÆ.

Acorus calamus L. Sweet Flag, Swampy ground. July 24, 1899.

LEMNACEÆ.

Lemna trisulca L. Ivy-leaved or Star Duckweed. Ponds. Infrequent.

PONTEDERIACEÆ.

Pontederia cordata L. Pickeral Weed. Swampy ground and egdes of pond. Infrequent. July 24, 1899.

SMILACEÆ.

Smilax ecirrhata (Engelm.) S. Wats. Upright Smilax. Woods. Infrequent. May 23, 1898.

LILIACEÆ,

Quamasia hyacinthiana (Raf.) Britton. Wild Hyacinth. Once reported to this academy as *Zygadenus elegans* Pursh. Frequent locally. May 23, 1898.

ORCHIDACEÆ.

Cypripedium candidum Willd. Small White Lady's Slipper. A bunch of four found on a seepy bluff. May 28, 1904.

Leptorchis liliifolia (L.) Kuntze. Large Twayblade. Woods. Rare. July 21, 1900.

SALICACEÆ.

Salix fluviatilis Nutt. Sandbar Willow. Along streams.

POLYGONACEÆ.

Rumex crispus L. Curled Dock. Fields and waste places.

Rumex patientia L. Patience Dock. Along a roadside near Leon.

Rumex obtusifolius L. Broad-leaved or Bitter Dock. Fields and meadows. Introduced with clover seed.

Polygonum orientale L. Prince's Feather. Waste places. September 10, 1898.

Polygonum incarnatum Ell. Slender Pink Persicaria. Wet fields and wastes. August 18, 1898.

Polygonum lapathifolium L. Dock-leaved Persicaria. Fields and wastes. A weed. July 15, 1898.

Polygonum punctatum Ell. Water Smartweed. Wet soil. Collected several times.

CARYOPHYLLACEÆ.

Silene noctiflora L. Night-flowering Catchfly. Fields and wastes. Introduced in clover seed. June 27, 1902.

Cerastium vulgatum L. Larger Mouse-ear Chickweed. Grows in waste places. Is not as widely distributed locally as *C. longipedunculatum* Muhl.

NYMPHÆACEÆ.

Nelumbo lutea (Willd.) Pers. American Nelumbo or Lotus. In a pond near the Weldon river. July 28, 1900.

BERBERIDACEÆ.

Berberis vulgaris L. European Barberry. Occurs on the border of a wood southwest of Lamoni.

CRUCIFERÆ.

Camelina sativa (L.) Crantz. Gold of Pleasure. False Flax. One specimen found in a meadow. May 6, 1902.

ROSACEÆ.

Fragaria americana (Porter) Britton. American Wood Strawberry. Woods. Frequent. May, 1898.

PAPILIONACEÆ.

Trifolium reflexum L. Buffalo Clover. A single plant found on a wooded bluff. June 6, 1898.

Astragalus distortus T. & G. Bent Milk Vetch. Dry prairie soil. May 26, 1903.

Lespedeza virginica (L.) Britton. Slender Bush-clover. Dry open woods. September 13, 1902.

HYPERICACEÆ.

Hypericum ascyron L. Great Saint John's Wort. Occurs in some bushland north of Lamoni. July 21, 1900.

VIOLACEÆ.

Viola domestica Bicknell. Yard Violet. In cultivated soil. Rare. September 28, 1897.

THYMELEACEÆ.

Dirca palustris L. Leather-wood. Woods along Grand river. Frequent locally.

HALORAGIDACEÆ.

Myriophyllum pinnatum (Walt.) B. S. P. Pinnate Water-milfoil. Ponds. August 10, 1899.

CORNACEÆ.

Cornus circinata L. Her. Round-leaved Dogwood. Borders of woods, etc. May 29, 1904.

PRIMULACEÆ.

Steironema lanceolatum (Walt.) A. Gray. Lance-leaved Loosestrife. Wet soil. Frequent on the lowlands of Grand and Little rivers.

ASCLEPIADACEÆ.

Asclepias sullivantii Engelm. Sullivant's Milkweed. Moist soil. July 22, 1903.

Asclepias exaltata (L.) Muhl. Poke or Tall Milkweed. Woods. Infrequent. June 15, 1901.

Asclepias quadrifolia Jacq. Four-leaved Milkweed. Woods. Infrequent. June 15, 1901.

VERBENIACEÆ.

The following hybrids have been recognized:

Verbena hastata X *V. stricta*.

Verbena urticifolia X *V. bracteosa*.

LABIATÆ.

Physostegia virginiana (L.) Benth. False Dragon-head. Abundant in a swale near Grand river. August, 1899, but not since observed.

SCROPHULARIACEÆ.

Scrophularia laporella Bicknell. Hare Figwort. Several specimens found along the railroad right of way east of Lamoni. May 27, 1903.

Monniera rotundifolia Michx. Round-leaved Hedge-hyssup. A small quantity found along the edge of a railroad pond near Davis City. August 13, 1903.

CAPRIFOLIACEÆ.

Lonicera sullivantii A. Gray. Sullivants Honeysuckle. Wooded bluffs. Rather infrequent. June.

CUCURBITACEÆ.

Sicyos angulatus L. One-seeded Bur-cucumber. A quantity found along the roadside near Leon. September 4, 1899.

CICHORIACEÆ.

Sonchus oleraceus L. Annual Sow-thistle. Waste places. Frequent about towns.

Nothocalais cuspidata (Pursh.) Greene. False Calais. Dry rocky roadsides. May 17, 1902.

COMPOSITÆ.

Erigeron annuus (L.) Pers. Daisy Fleabane. Sweet Scabious. Meadows and pastures. Common. June 6, 1898.

THE SWITCHBOARD AND ARRANGEMENT OF STORAGE BATTERY AT SIMPSON COLLEGE.

BY JOHN L. TILTON.

As it has not been possible for us to have the street current in the daytime, nor up to the present to have our own lighting plant, it has been our custom for several years to charge storage cells in the evening by means of a 110-volt street current passed through a water rheostat. This method of reducing the current was so unsatisfactory that we purchased a rotary transformer, one end of which is a motor, run by the 110-volt current, the other a 15-volt dynamo, and installed a suitable storage battery. The plan of the arrangement of battery and switchboard, which has proved very satisfactory, may be of value to others.

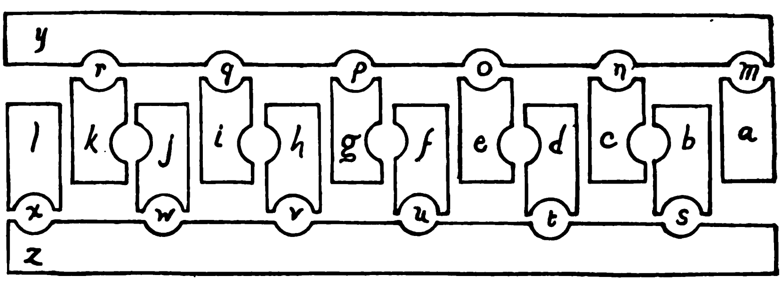


FIG. 4. Diagram of the switchboard.

The different blocks of brass $\frac{3}{8}$ of an inch thick are screwed, as illustrated, to a block of wood-fibre through which the necessary wires pass. From *a*, as marked in the diagram, a wire runs to the positive pole of the first cell, from *b* a wire runs to the negative pole of the first cell, from *c* to the positive pole of the second cell, from *d* to

the negative pole of the second cell, and so on for the central line of blocks; *a* and *l* are also connected by separate wires to a knife-switch. When plugs are inserted in the central line of holes (*bc*, *de*, *fg*, etc.), the battery is in series ready to be charged on closing the knife-switch in the circuit. When charged and the knife-switch to the dynamo thrown open several combinations are possible with the brass bars *y* and *z* from which wires run to another knife-switch connected with the laboratory circuit.

If plugs are inserted at *m* and *s* connecting the first cell with the bars *y* and *z*, the current from that cell alone may be used in the laboratory circuit. Two or more cells, or the entire battery, may in a similar manner be connected in parallel. If a plug is inserted at *m*, another at *bc* and a third at *t*, the two cells may be discharged in series. In a similar manner any two adjacent cells may be connected in series, or four may be used in two series of two each, or the entire battery used in three series of two cells each. If plugs are inserted at *m*, *bc*, *de*, *fg*, and *u*, the first three cells are connected in series. In a similar manner any three adjacent cells may be connected in series, or the battery as a whole connected in two series of three cells each. If plugs are inserted at *m*, *bc*, *de*, *fg*, and *v*, the first four cells are in series. In a similar manner any four adjacent cells may be combined in series. Either of the two sets of five adjacent cells may also be thus connected in series, or all six connected in series.

If one or more of the cells should be removed, the ends of the wires that had been connected to the cell can be fastened together and the remainder of the battery used in series, or in any of the combinations of cells, omitting the group to which the cell that has been removed belonged.

A voltmeter indicates two volts for each cell by itself. For the different combinations mentioned the voltages indicated are four, six, eight, ten and twelve respectively.

The battery of six cells is arranged in a single line on a shelf close to the switchboard. Should it ever become

FIG. 1. The switchboard, battery and transformer.

FIG. 2. The switchboard, with plugs arranged for discharging the battery in series.

desirable to increase the capacity without purchasing larger cells a second series of cells may be placed on a shelf below the one now used and each pole of the cells now placed may be connected with the corresponding pole of a cell on the shelf below, thus requiring no change whatever in the switchboard.

It is possible to short-circuit the first cell by inserting plugs at *m*, *bc* and *n*. In a similar way any one cell, or any series of successive cells up to five in number, may be short-circuited. There is, however, no difficulty experienced, for no combination that will short-circuit a cell is required, and if made by accident during the time it takes to adjust the plugs the mistake does no harm. A cell left short-circuited for five minutes dropped in voltage from two to one and one-half, but in another five minutes it had regained its original voltage.

The rotary transformer itself is very convenient for evening work. By means of a starting rheostat which is also a speed controller various voltages may be secured. A series of tests gave the following voltages: $10\frac{1}{2}$, $11\frac{1}{2}$, $12\frac{1}{2}$, $13\frac{1}{2}$, 14, $14\frac{1}{4}$, $14\frac{1}{2}$, 15. The amperage necessary to run the motor dropped from close to $3\frac{3}{4}$ when the $10\frac{1}{2}$ volts were generated to about $2\frac{3}{4}$ when the 15 volts were generated.

Opposite segments of the motor are tapped to collector rings from which an alternating current may be carried to the laboratory circuit through a separate switch when an alternating current is desired. A four-inch pulley attached to the axle of the motor makes it possible to obtain power. It is expected that when a gasoline engine is secured the motor will serve as a dynamo, thus giving three dynamos of different voltages from any one of which a current may be obtained.

A PROBLEM IN MUNICIPAL WATERWORKS FOR A SMALL CITY.

BY JOHN L. TILTON.

The problems of a municipal water supply, not only for e protection but also for domestic use, are important ones nfronting numerous towns in Iowa. The attempt to lve those problems at Indianola presents features of neral as well as local value.

After the drought of 1894-5, when not only the cisterns d shallow wells but even the rivers went dry, the city ted to put in a system of waterworks. Since bonds to e full amount allowed by law had already been issued on electric light plant, the city was unable to become the le owners of the proposed plant; but arrangements were ide with a waterworks company in Chicago, whereby that mpany undertook the work with the city nominally the ner. The method of procedure in the early part of the rk was a good illustration of how *not* to proceed. It is assumed that the nearest supply that was sufficient in antity was also satisfactory in quality, and the work gun was continued regardless of the fact that it was on found that the water was a mineral water. I am not are of any attempt to learn what the minerals in solu- n were and what effect their presence would have on e acceptance of the water by the public. The committee d the parties from Chicago went ahead as if a plan which rked all right in some other places would prove satis- ctory at Indianola whatever the conditions. After the rk was completed opponents of the measure tested the ntract at law and proved the arrangements relating to nership illegal. Because of this decision the Chicago

parties became the sole owners of the plant. Later the firm failed and the city operated the plant for several months until, this last spring, a private company studied the difficulties involved and bought the depreciated stock.

The interesting geological problems associated with this subject I wish to reserve for a future paper and consider here only problems related to municipal waterworks apart from those strictly geological.

It is desirable to have the waterworks plant as near the city as possible and near a railroad by which coal may be obtained. First, then, let us consider the facts on which the possibility of locating the plant near the city depend. This involves the general relation of run-off to precipitation, which is applicable both at Indianola and in a general way at all other places, and conditions which are peculiar to the location.

The ultimate source of supply is rainfall, either sufficiently local to affect our rivers and shallow wells, or in some region more remote where it may ultimately get into a porous stratum and find its way beneath a city where it can be obtained in deep wells.

Evidently the cheapest supply and that first to be sought is the one at the surface. The presence of running water in a draw or ravine in dry weather seems to suggest that all one need do is to sink a few wells and the supply is obtained, regardless of the area drained or the character of the deposits from which the trickling water may have come. This water, like the water in the streams, came from ground water, the original source being, near Indianola at least, a quite local rainfall. The consideration of precipitation, run-off and evaporation is rendered especially important because in at least the street corner discussions, some have advocated the sinking of a battery of shallow wells in the uplands west of the city, or locating a reservoir a mile east of the city, expecting to obtain a full supply at either place, those favoring the latter location basing their opinions on the reported approval of a Chicago engineer who visited the city, gave a casual glance at the surface and listened to various statements.

A recent government report states that in studying the rainfall with reference to reservoirs it has been found advisable to divide the year into three periods: for storage, growing and replenishing. From our own data on rainfall we find the following result for one square mile:

CATCHMENT AREA, ONE SQUARE MILE.

	Minimum Rainfall.	Average Rainfall.
Storage Period, Dec.—May, 182 days..........	6.36 inches.	12.48 inches.
Growing Period, June—Aug., 92 days.........	2.64 inches.	11.88 inches.
Replenishing Period, Sept.—Nov., 91 days....	2.95 inches.	6.41 inches.

One inch of rainfall over a square mile of surface gives 17,378,743 gallons. The local precipitation in gallons for the storage, growing and replenishing periods is as follows:

	Minimum Rainfall.	Average Rainfall.
Storage Period....	88,457,802 gallons.	216,886,713 gallons.
Growing Period...	4,518,473 gallons.	20,680,704 gallons.
Replenishing Period.............	12,165,120 gallons.	26,415,689 gallons.

Our city even now with a water supply not generally acceptable is said to use about 75,000 gallons per day in addition to the large amounts from cisterns and wells, while the supply that is looked for is 3,500,000 gallons. In Boston the water used was 119 gallons per inhabitant per day in 1903.

On this basis the present amount required for Indianola would be 416,500 gallons per day, but plans for the future should allow for possible growth. We know that prior to the installation of water works the people of our city did get along with the rainfall, though it was frequently embarassing as wells and cisterns frequently give out. In the drought of 1895 there were fears of a serious conflagration. When the supply is not carefully treasured in cisterns and doled out by the dipperfull, a much larger supply is necessary. Then, the greater the drought the larger the amount of water used for streets, lawns and gardens, and

the more imperative is the demand for fire protection; all this at the very time when the supply is near its minimum. It is evident that the minimum precipitation is the precipitation that must be considered. The government report* already mentioned gives us the relation of run-off and evaporation to precipitation in the storage and growing periods but not in the replenishing period; for this the average of thirty-seven records given in the tables in the same pamphlet is assumed to be correct. For the rainfall at Indianola the figures are as follows:

RUN-OFF AND EVAPORATION.

	Run-Off.	Run-Off.		Evaporation.	
		Minimum.	Average.	Minimum.	Average.
During Storage Period......	80 %	5.09 in.	9.98 in.	1.27 in.	2.50 in.
During Growing Period ...	10 %	.26 in.	1.19 in.	2.38 in.	10.69 in.
During Replenishing Period.	28.7%	.70 in.	1.52 in.	2.25 in.	4.89 in.

The loss by evaporation of water stored in a reservoir is at a different rate than the loss by evaporation from the surface of the ground. The record for Lake Cochituate† for thirty-eight years gives the following averages:

	Mean Precipitation.	Mean Evaporation.	Evaporated.
Storage................	23.15 inches.	8.23 inches.	35.5 per cent.
Growing...............	11.59 inches.	9.51 inches.	82 per cent.
Replenishing........	12.38 inches.	9.06 inches.	73 per cent.

Indianola is situated on a divide which is thoroughly drained. The nearest places toward which the drainage is sufficient to supply even the demand for half a million gallons daily are the river bottoms, one, a mile south of the city, the other, six miles north. The location already spoken of as a mile east of the city is at a point where the rock formation is unusually good for a dam; but the area drained past that place is only one square mile. As this location is close to a railroad by which a supply of coal

*Water Supply and Irrigation Paper No. 80.

†Water Supply and Irrigation Paper No. 80, page 89.

may be easily obtained, the possibility of obtaining water from deep wells must not be overlooked. The following table gives data concerning the quality of water found in deep wells penetrating the same strata from which a supply at Indianola would be obtained:

Place.	Test.	Acceptability.	Level of surface of water.	Authority.
Greenwood Park.	576,000 gals. per day	?	872 A. T......	Iowa Geol. Surv., Vol. VI, p. 294.
Pella	360,000 gals. per day	Not acceptable	768 A. T......	Iowa Geol. Surv., Vol. VI, p. 310.
Grinnell	151,200 gals. per day	Acceptable	798 A. T......	Iowa Geol. Surv., Vol. VI, p. 287.
Sigourney	?	Not acceptable	726 A. T......	Iowa Geol. Surv., Vol. VI, p. 305.
Centerville	50,400 gals. per day	Acceptable.....	787 A. T......	Iowa Geol. Surv., Vol. VI, p. 327.
Boone	100,800 gals. per day	Not fully acceptable . . .	940 A. T.. ..	Iowa Geol. Surv., Vol. VI, p. 252.

From this table it is far from certain that an acceptable quality of water would be secured from a deep well. To reach the deepest strata from which water is obtained in the above mentioned wells (the Saint Peter and Saint Croix sandstones) the well at Indianola would have to reach a depth of 1800-2200 feet. The receipts, which are at present only about $2,500 per year, will not warrant expenditure on such an uncertainty.

If the necessary quantity and quality of water alone were to be considered the place where the pumping station ought to have been located is just north of Middle river, six miles north of Indianola, on a strip of "second bottom" land which extends southward to near the river. Here, at a depth of only twenty-five feet below the second bottom, the sands contain an inexhaustible supply free from iron. The drainage area up the river from this place is about four hundred and eighty square miles. Should the river itself go dry, as it did in 1895, the sand below the bed of the river could be relied upon to furnish a supply during the drought. At this point the pumping station would be within half a mile of a railroad on a level bottom land over which a branch road could be easily laid, and near coal mines from which coal could also be hauled in

wagons. But a change in the location of the pumping station from about two miles southwest of the city to six miles north is for the present out of the question. Even using as much as possible of the material now owned the cost of the change would be about thirty thousand dollars.

At the present location of the pumping station, southwest of the city, there is an abundance of water from a drainage area of 281 square miles. The entire flat near and above the plant is underlain by sand containing water charged with an abundance of iron bicarbonate, but it is not yet known whether this condition of the water actually persists in the bottom land down the river. It has already been found that the water, though wholesome and perhaps endurable so far as taste is concerned, is wholly unacceptable for cooking and for bathing. The iron can be precipitated by lye or by ammonia and the water strained, or it can be quite fully removed by allowing it to stand exposed to the air and then filtering it; but such processes are too troublesome to be acceptable. I have not been able to ascertain, either from published data or from experiment, whether iron bicarbonate in solution under pressure can be precipitated either by alum or ammonia and can be immediately filtered out under pressure as a fine sediment can be treated. This may be possible, for iron bicarbonate is very unstable, but as pressure is so effective in maintaining the bicarbonate of iron it must be proven that the bicarbonate can be so removed before it would be advisable to install a pressure filter. Without this evidence water that is free from iron must be obtained from some other local source.

There is on the opposite side of the river from the pumping station a point of land in a large bend of the stream. The sand in the distant part of this bend and nearest the upland is charged with iron, but it is not known whether the sand which lies where the circulation of the ground water from the upper limb of the bend to the lower limb may not be washed free from iron, for the stream itself, of course, has no iron in solution. While it is possible that

wells located on the inside of this bend near the river may be sufficiently free from iron, it is probable that water from beneath and from the upland side may carry iron in solution into such wells. This can only be determined by driving a few wells and analyzing the water; but, as even a small quantity of iron in solution is so very undesirable, the chances of securing a satisfactory supply are not very attractive.

The last possibility is to filter the water from the river itself. Here the difficulty is to filter out the bacteria and the very fine clay which is so slow in settling, and after a rain, to dispose of the mud which the river carries in abundance. If the "English method" of filtration were used, 17,424 square feet of filtration surface would be needed per million gallons. This would require a trench twenty feet wide and 871 feet long, or two trenches each at least half as long, that the surface of one filter may be cleaned while the surface of the other is flooded. A filter placed in the bed of the river would answer for a while, but it would not be conveniently placed for care. If 500 feet were placed in the river bed and 500 feet in a new trench, a total excavation of at least 46,611 cubic yards would be required, 12,666 cubic yards of sand and gravel for the filter, and 16,000 feet of tile for the bottom of the filter, besides controlling gates and a receiving well.

If the "American method" of quick filtration is employed a centrifugal pump is needed, settling basins, and tanks for sand filters. At one grain of alum per gallon of water it would require 143 pounds of alum per million gallons as a coagulant of the fine clay. The bacteria will be caught in the coagulated clay and filtered out at the same time. This method can with reasonable care give the city the water supply which it needs. It seems the only method that is feasible.

The company which has recently bought the plant is now installing two settling tanks each with a capacity of 43,000 gallons and two filtering tanks each ten feet in diameter in which the sand forming the filter is to be three and one-half feet deep. It is also proposed to put in a battery of wells in gravel west of the city where there is good water and pump whatever can be obtained there directly into the main, using a gasoline engine and an automatic pump.

SOME RAILROAD WATER SUPPLIES.

BY L. H. PAMMEL AND ESTELLE D. FOGEL.

Complaints are frequently made with reference to railroad water supplies. These complaints come from passengers as well as stockmen who are compelled to use the water for their stock.

To study some of these problems investigations were made of a number of the railroad wells of this state as well as some along the Northern Pacific railroad in Dakota and Montana. The work is not completed but the facts obtained may be of interest to the users of these public water supplies.

It may be of interest to state that the water supply of one municipal corporation, which was also used by the several railroads entering the city, contained Colon Bacillus. It makes it extremely desirable that railways should be very careful of the water used for their passengers. The railroads have, no doubt, in some cases been responsible for the conveyance of typhoid fever. The railroad water supply should be examined chemically and bacteriologically from time to time. The chemical analyses appended were submitted by Dr. J. B. Weems and C. E. Ellis.

Quite a number of different species have been found. In well waters from the west the following species have been determined.

Planosarcina mobilis (Maurea) Migula, *Micrococcus cinnabareus* Flügge, *Micrococcus coralinus* Centanni, *Bacterium glaucum* Maschek. *Bacillus aurescens* Ravenel, mealy orange.

TABLE SHOWING BACTERIOLOGICAL

Where Located.	Temperature of water.	Date of plating.	Date of counting.	Depth of well.	Geological formation.	Character of Media			
						Agar.	Agar.	Agar Litmus Lactose.	Agar Litmus Lactose.
		1904							
C. & N.-W., Ames	......	June 22	June 25	......	*a*	70	......	20	10
Belle Plaine	......	July 7.	July 9	35	*b*	790	560	......	......
			July 15			800	800	......	310
Boone	......	June 10	June 12	......	Drift	10	......	30	......
Carroll	......	May 28	May 29	......	*c*	....	......	......	10
						....	50	......	10
			May 31			40	10	30	40
Co. Bluffs	......	June 14	June 16	......	......	250	1050	420	......
			June 18	......	......	300	1050	420	150
Eagle Grove	51° F	June 20	June 23	......	Drift	....	......	......	......
			June 25			100	160	80	140
Elmore	......	Sept. 6	Sept. 9	......	Drift	190	......	......	......
			Sept. 10						
Glidden	......	June 21	June 24	......	......	36000	42000	44000	17500
LaMoille	51° F	July 30	Aug. 1	30	Drift	......	......	250	200
Mason City	50° F	July 7.	July 9	862	St. Peter	790	560	......	......
			July 18			....	1800	......	......
Mo. Valley	......	June 15	June 16	70.	Alluvial	......	....	......	......
			June 18		Silt	40	50	10	......
Tama City	......	July 7.	July 9	......	Gravel	850	250	......	..
			July 15	......	Drift	850	450	......	1400
Webster City	55° F	June 20	June 23	......	Drift	55	100	......	20
			June 25			1000	350	330	200
Marshalltown	......	Nov. 28	Dec. 3	......	......	220	330	230	200
C. G. W., Marshalltown	......	Nov. 28	Dec. 3	......	......	250	300	......	......
I. C., Marshalltown	......	Nov. 28	Dec. 3	......	......	1500	160	1250	300
		1905							
C., B. & Q., Clarinda	50° F	Jan. 16	Jan. 24	......	......	865600	767500	......	......
Creston	45° F	Jan. 16	Jan. 24	60.	......	560	......	......	......
Villisca	35° F	Jan. 16	Jan. 24	*	......	65600	....	......	......
		1904	1904						
N.P. Billings (Yellowstone river)	68° F	Aug. 16	Aug. 19	......	......	4200	2800	2450	2000
N.P. Glendive (Yellowstone river)	68° F	Aug. 14	Aug. 16	......	......	40	10500	60	250
			Aug. 18	..	......	....	14000	3200	......
Miles City	51° F	Aug. 15	Aug. 19	20.	*d*	80	240	190	1200
Fargo	......	Aug. 12	Aug. 14	......	......	1400	20	1400	4200
			Aug. 16	......	......	2800	2700	5600	4200
C., R. I. & P., Des Moines	......	Dec. 15	......	......	......	1000	......	......	......
C. & N.-W., Des Moines	......	Dec. 15	......	......	......	1400	......	......	......
U. R., Des Moines	......	Dec. 15	......	......	......	400	......	......	......

* From Nodaway R.

a Sand and gravel, base of Wisconsin drift.

b Alluvial silt gravel.

c Gravel, base of Wisconsin drift.

d Alkali silt.

RESULTS OF RAILROAD WELL WATERS.

and Number of Organisms per c. c.								
			Glucose Bouillon.					
Gelatine.	Gelatine.	Liquefying.	CO_2	Vol.	H.	Vol.	Acid species.	Remarks.
40	30	10	....	....	....	....	....	Water clear, colonies all white.
....	....	....	....	....	....	....	....	Water clear from tank. Carried through pipes one mile.
....	....	....	37.58	1.1	62.42	1.8	....	
....	....	....	....	....	.5	....	....	Water clear, rapid, colonies white.
....	....	....	....	....	....	....	....	
....	210	10	....	....	....	....	....	*Sarcina lutea* 10, water clear.
....	....	....	....	....	....	....	....	
10	140	....	....	....	....	....	....	Water somewhat turbid, all white.
Liquefied	Liquefied	....	40.54	3	59.46	4.4	30	Uses city water from Mo. river.
40	30	....	....	....	....	....	....	*Sarcina aurantiaca* 10, water clear.
70	30	....	57.89	5.5	42.11	4	....	
....	....	....	....	....	....	....	....	Water clear, white colonies.
3500	5600	100	....	....	....	....	....	Water collected on June 9 in sterile tubes and shipped to Ames.
....	....	....	33.33	1.6	66.67	3.2	....	Water clear.
....	....	....	....	....	....	....	....	Normal level 24 feet, water clear, all colonies white.
....	....	....	25	.5	75	1.5	....	
....	10	....	....	....	....	....	....	Water clear, white colonies.
....	....	....	....	....	....	....	....	
250	....	....	....	....	....	....	....	Water clear from tank
250	....	....	....	....	....	....	....	Water plated after five hours.
....	....	....	....	....	....	....	....	Water from tank clear, all colonies white.
....	....	....	27.77	.5	72.23	1.3	....	
200	130	300	....	....	....	....	....	
....	....	....	....	....	....	....	....	
....	....	....	....	....	....	....	....	
Liquefied	....	....	....	....	....	....	....	No gas.
Liquefied	....	....	....	....	....	....	....	
Liquefied	....	....	....	....	....	....	....	10 minutes pumping, water clear and rapid.
....	....	....	....	....	....	....	....	Alkaline.
....	....	....	....	....	....	....	*i*	Water turbid, temperature 70° F. Pumped from river in tank.
....	....	....	....	....	....	....	....	
....	....	....	....	....	....	....	....	Water clear, alkaline.
....	....	....	....	....	....	....	....	Water turbid, taken from Red river, 200 yellow colonies.
....	....	....	....	....	....	....	300	
....	....	....	....	....	....	....	....	
e 720 liq.	*f* 670 liq.	....	*g*	2	*h*	3	....	

e 400 non-liq., 250 liq.
f 460 non-liq., 8 liq.
g Present.
h Present.
i Acid species present.

Several other species were also identified, but in some cases the identification is doubtful. Of these one is a new species of Sarcina occurring in capsules and of a canary color. Of the rod-shaped organisms are Bacterium n. sp. color oleaginous, Bacterium near *B. Havaniensis*, rose pink, and a Bacterium of lemon yellow color. These colors are described as they appeared on nutrient agar.

Biological and morphological characters were determined. Under the latter head a study was made of the form and arrangement of the organisms. On the different media, the size, staining powers, motility, spores, and such special characters as capsules, involution forms, etc., were studied under the one-twelfth Homogeneous oil immersion lens.

The biological characters were determined from their growth in the following media: gelatin plate, agar plate, milk, litmus milk, blood serum, gelatin stab, agar stab, agar slant, potato streak, lactose bouillon, glucose bouillon, saccharose bouillon, anærobic glucose agar, Dunham's solution, litmus agar. In all cases duplicate cultures were made.

TABLE SHOWING RESULTS OF WELL AT AMES FOR ONE WEEK.

Place.	Date Plated, 1904.	Agar.		Lit. Agar.		Gelatin.		Temperature.	Remarks.
C. & N.-W., Ames...	Nov. 29.	5400	4800	....	....	900	600	....	No gas.
C. & N.-W., Ames...	Nov. 30.	380	500	....	....	560	500	....	No gas.
C. & N.-W., Ames...	Dec. 2..	840	1000	....	....	Lique.	Part lique- 480	....	No indol.
C. & N.-W., Ames...	Dec. 3..	750	...	....	....	Lique.	Lique.	....	No indol.
C. & N.-W., Ames...	Dec. 5..	280	....	....	...	Total liq.	Total liq.	65° C.	No indol.
C. & N.-W., Ames...	Dec. 8..	52	40	100	140	500	....	....	No indol.
C. & N.-W., Ames...	Dec. 9..	230	170	200	180	Part liq.	250 Non-liq.	....	*

*Lit. agar incubated at 37½° C.

CHEMICAL ANALYSIS.

Name of well.	Free Ammonia.	Albuminoid Ammonia.	Chlorine.	Solids on evaporation.	Solids on evaporation. 180° C.	Solids on ignition.	Nitrogen as Nitrites.	Nitrogen as Nitrates.	Oxygen consumed boiling 10 minutes.
C. & N. W. at Carroll	2.12	.07	3.5	504	500	448	Trace	.30	1.20
C. &. N. W at Boone after use of lime..	1.80	.056	7.	184	172	146	.04	None	1.10
C. & N. W. at Boone before use of lime	1.91	.094	4.	482	451	404	None	None	2.10
C. &. N. W. at Mo. Valley............	1.66	.07	27.	958	932	814	None	None	.75

FLOWERING PLANTS OF HENRY COUNTY.

BY J. M. LINDLY.

Henry county is the second from the Mississippi river on the east and the second county north of the Misssouri state line on the south, thus placing it in the southeast part of the state of Iowa.

Fully one-half, possibly two-thirds, of the county was originally timberland. The remainder is high rolling prairies.

Beginning near the northwest corner of the county, Skunk river flows southward along the boundary between Henry and Jefferson counties, alternating first in one county and then in the other, for a distance of twelve miles, when it takes a southeast course across the southern portion of the county, leaving it about two miles west of the southeast corner. The timber belt of Skunk river in this part of the state ranged in width from ten to fifteen miles. While passing through this county, Skunk river receives three tributaries worthy of mention, Big creek, Big Cedar creek and Mud creek.

Big creek describes a semi-circle and, with its branches, Brush creek, South Branch Big creek, North Branch Big creek, Linn creek and Brandywine creek with its branch, Little Potomac creek, occupies the south central portion of the county. Big creek and most of its branches were originally wooded with a belt from one-half to two miles in width.

Big Cedar creek enters Henry county from Jefferson county near the southwest corner of the former and flows north into Skunk River. The timber along this stream was from two to four miles in width.

Mud creek is in the southeast part of the county with an original timber belt of several miles.

The northeast part of the county is devoid of timber except a strip about a mile wide, or a little less, along the east branch of Crooked creek in Scott township. This branch of Crooked creek is sometimes called the South Fork of Crooked creek, but is commonly known in this locality as simply Crooked creek. The soil of this part of the county is a black, rich loam, several farms having been sold in recent years at prices ranging from $100.00 to $115.00 per acre.

The specimens to be here enumerated were mostly gathered in Scott township, from the open prairie district unless otherwise stated. Very little of the original soil in the prairie district remains untouched by the plow. In untiled sloughs may be found primitive conditions, but such instances are now rare. The timber along Crooked creek has been cleared away to a great extent and the land put under cultivation. Where the timber still stands, the hoof of the herd has eradicated the primitive denizens of the soil to such a degree that one must need seek the secluded nook for the aboriginal plant; and even then it may be missing.

About fifteen years ago the writer collected a few hundred specimens of flowering plants growing mostly in Scott township in the extreme northeastern corner of Henry county. The list here submitted is the first installment of this collection. It is the desire of the writer that, in the brief intervals of a busy life, he may find time in which not only to prepare the remainder of the above collection for the proceedings of this Society, but that he may supplement his earlier work by a continued and more extended research covering the whole county.

An apology for the use of dates and location in the description of a plant may be found in the statement that science is exact, is comprehensive rather than abbreviative. One knows just where and when a certain plant was once found. We give it a "habitation and a name," even a

location in point of time. If later investigation should determine a plant to be missing, it may be inferred that the varying conditions thrust upon it by the hand of man have worked its extermination.

ARACEÆ.

Arisæma triphyllum Torr. Jack-in-the-pulpit. Indian Turnip. Dragon Root. Rare in this part of the state. Found growing in the woods at Branigar Park, near the village of Coppock, near northwest corner of Henry county and along Skunk river. Specimen procured by Miss Jennie Lindly, May 11, 1895.

ASCLEPIADACEÆ.

Asclepias verticillata L. Milkweed. Specimen mounted, August 11, 1890.

BIGNONIACEÆ.

Tecoma radicans Juss. Trumpet Flower. Trumpet Creeper. Growing, August 24, 1890, in front yard of D. M. Rittenhouse's home, formerly known as home of Rev. J. M. Henderson, in Winfield. Think I have seen it growing in the woods along Crooked creek; but, if so, it is very rare.

CAPRIFOLIACEÆ.

Viburnum lentago L. Sweet Viburnum. Sheepberry. Was growing on the premises of the home of Hon. Washington Mullin, at Winfield, May 21, 1891.

CARYOPHYLLACEÆ.

Dianthus armeria L. Deptford Pink. Wild Pink. At the home of Mrs. Clarissa Beauchamp, in Winfield, July 11, 1892.

COMPOSITÆ.

Achillea millefolium L. Common Yarrow or Milfoil. Growing in the pasture just south of the premises on the farm of B. B. Lindly, adjoining town of Winfield, July 21, 1890. Common.

Ambrosia artemisiæfolia L. Ragweed. Hogweed. Roman Wormwood. Growing on waste places everywhere whose soil has at sometime been under cultivation. September 10, 1890.

Aster azurius Lindl. A blue aster. Growing in the woods along Crooked creek just east of Winfield, September 29, 1890.

Aster simplex Willd. Found growing in the woods along Crooked creek just east of Winfield, September 29, 1890.

Bidens cernua L. Smaller Bur-Marigold. Common along the ditches and in moist places. September 14, 1890.

Bidens frondosa L. Beggar-ticks. Stick-tight. Growing in moist places where soil has been broken or under cultivation. Specimen taken from lot in rear of B. B. Lindly's drug store in Winfield, September 10, 1890.

Cnicus altissimus Willd. As described in Gray's Botany. In Wood's it is mentioned as *Cirsium altissimum* Spr. A very tall thistle. Specimen found on vacant lot immediately north of B. B. Lindly's store building in Winfield, September 11, 1890.

Cirsium discolor Spr. According to Wood. Gray gives it as a variety of *Cnicus altissimus*, Willd. Common. Specimen found growing along the Iowa Central railway just east of its depot in Winfield. September 14, 1890.

Dysodia chrysanthemoides Lagasca. False Dog-fennel. Fetid Marigold. Common, usually along the waysides. September 22, 1890.

Erigeron strigosum L. A Fleabane or Whiteweed. Common. Specimen growing in pasture on north hill on B. B. Lindly's farm. June 17, 1892.

Eupatorium altissimum L. A member of the Boneset family. Specimen found growing along the road north from Winfield. September 10, 1890.

Helianthus divaricatus L. A specimen of the Sun-Flower family. Specimen growing along the Iowa Central railway just east of its depot in Winfield, September, 14, 1890.

Helianthus tracheliifolius Willd. A member of the Sun-Flower family. September 10, 1890.

Lappa officinalis, Allioni. This is the name by which it is known to the Materia Medica. Gray describes it under the name of *Arctium lappa* L. Common in waste and cultivated grounds. Known to the people as Burdock. Specimen mounted August 2, 1890.

Solidago puberula Nutt. A member of the Goldenrod family. Growing along the fence between the Lindly and Morley farms. September 21, 1890.

Taraxacum Dens-leonis Desf., as named in Wood's Botany. In Gray's Manual it is named *Taraxacum officiniale* Weber. The former term is that by which it is known in medicine. Dandelion. Very common in pastures, meadows and waysides.

Xanthium strumarium L. Cocklebur. Clotbur. Sheep-bur. Growing about the farmyards, and particularly in the grain and cornfields. September 10, 1890.

CONVOLVULACEÆ.

Calystegia sepium L. Hedge Bindweed. Rutland Beauty. A morning-glory. Somewhat common in this locality on cultivated ground, a tenaceous pest difficult of extermination. On residence lot of B. B. Lindly in Winfield, July 19, 1890. Fifteen years later, it is still found on the same lot, mowed down every year, and without encouragement.

CRASSULACEÆ.

Sedum telephium L. Live-forever. Garden Orpine. Growing along the fence in front of the old homestead on the B. B. Lindly farm, where it had flourished for many years before the gathering of this specimen, September 15, 1890.

CRUCIFERÆ.

Dentaria laciniata Muhl. Toothwort. Pepper-root. Su is the description in Gray's Manual. In Wood's Botany is described as *Cardamine laciniata.* A bitter cress. Fou east of Burlington & Northwestern railroad depot at Wi field, April 29, 1892.

GENTIANACEÆ

Gentiana andrewsii Griseb. Closed Gentian. Clos Blue Gentian. Found growing in the slough, which w unbroken sod, on the west side of the Lindly farm, bei on the west side of the northwest ¼ of the southwest ¼ section 21, township 73 north, range 5 west, next to wh was then known as the Meeker farm, September 16, 18

GRAMINEÆ.

Hordeum jubatum L. Squirrel-tail Grass. A wild barl On or near the north hill of the Lindly farm, in pastu June 17, 1892.

Panicum sanguinale L. Thus described in Gray's Manu but in Wood's Botany it is called *Paspalum sanguinale* La Crab or Finger Grass. Panic Grass. August 11, 1890.

Setaria glauca Beauv. Foxtail Grass. Very common corn and stubble fields. August 11, 1890.

LABIATÆ.

Pycnanthemum lanceolatum Pursh. Wild Basil. Gro ing in the north pasture on the Lindly farm. July 1890.

LEGUMINOSÆ.

Baptisia leucophœa Nutt. Wild Indigo. Growing the prairie pasture, south of the barn at the homestead the Lindly farm. May 19, 1891.

LOBELIACEÆ.

Lobelia spicata Lam. Variety, *hirtella* Gray. North hill of the Lindly farm. June 17, 1892.

ONAGRACEÆ.

Gaura coccinea Nutt. A specimen of the Evening Primrose family. Growing along the line fence between the Morley and Lindly farms. September 21, 1890.

Œnothera biennis L. Common Evening Primrose. Growing along the Iowa Central railway in Patterson's field, just east of Iowa Central station. September 14, 1890.

PLANTAGINACEÆ.

Plantago major L. Common Plantain. Common along the wayside and near dwellings. July 16, 1899.

POLYGONACEÆ.

Polygonum dumetorum L. Climbing False Buckwheat. Hedge Bindweed. Knot Grass. August 11, 1890.

PRIMULACEÆ.

Dodecatheon meadia L. American Cowslip. Shooting Star. Pride of Ohio. A member of the Primwort or Primrose family. Specimen from dooryard of Mr. Waitman near Merrimac, in Jefferson township, on the edge of the Skunk River woods. June 5, 1892:

Centunculus minimus L. False Pimpernel. Chaffweed. Found growing in low moist ground in Lindly's north pasture field. Not common. May, 1890.

RANUNCULACEÆ.

Anemonella thalictroides Spach. As named in Gray's Manual. In Wood's Botany it is called *Anemone thalictroides* L. Rue Anemone. One of the wind-flowers belonging to the Crowfoot family. Specimen from the woods on east side of Crooked creek just east Winfield, procured by Miss Katherine H. Pierce, in April 1892.

Aquilegia canadensis L. Wild Columbine. Growing wild in the woods east of Skunk river, near Merrimac Mills, in Jefferson township, probably not far from the Waitman home on the southwest ¼ of section 33, township 73 north, range 7 west. Specimen procured by Miss Katherine H. Pierce, June 5, 1892.

ROSACEÆ.

Rosa humilis Marsh. Wild Rose. Growing in gravelly clay in the road on the hillside north of the Lindly homestead, south of Winfield. The roadway had been cut down into the gravelly clay where our specimen found a lodgement. June 17, 1892.

Spiraea lobata L. Queen of the Prairie. Meadow-sweet. Specimen growing in front dooryard at home of Mrs. W. B. Patterson in Winfield, July 14, 1892. The petals and sepals were mostly in fours instead of the typical fives. I have not seen this plant growing wild in this locality.

SAPINDACEÆ.

Æsculus flava Ait. Sweet Buckeye. Horse Chestnut Growing wild in the woods northwest of the village of Trenton, near residence of Mr. Waitman, May 22, 1892, and belonging to the Skunk river timber belt.

SAXIFRAGACEÆ.

Ribes floridum L'Her. Wild Black Currant. Specimen found growing in the extreme northwest corner of B. B. Lindly's farm, next to the premises of Daniel Morley, and at the crossroads and possibly along the hedgerow, May 13, 1891.

SCROPHULARIACEÆ.

Pentstemon pubescens Solander. Beard-Tongue. A specimen of the Figwort family. Found growing in the Skunk river woods near Merrimac Mills, June 5, 1892.

Verbascum thapsus L. Common Mullein. Not numerous, yet occasionally found. September 13, 1890.

BISECTION OF MOUNTAIN BLOCKS IN THE GREAT BASIN REGION.

BY CHARLES R. KEYES.

(Abstract).

An interesting phase of mountain structure has recently come to notice among the block ranges of the basin region of the southwest. As is well known, most of the basin ranges are long, narrow tilted blocks, arranged subparallel to one another, with intervals of twenty to forty miles of flat country between. These mountain blocks are fifty to one hundred miles in length and are tilted to heights of 3,000 to 5,000 feet.

In central New Mexico there are three ridges—the Sandia-Manzano, the Oscura-San Andreas, and San Cristobal-Caballos—which are essentially parts of single uplifts, but which are cut in two by deep canyons which connect the plains on either side. Why these ridges should be cleft in their highest parts has been puzzling. However, an interesting solution has been found.

In each of the three areas mentioned profound faulting has manifestly taken place since the time when the mountains were upraised, and the trend of the later dislocation has been transverse to the major faulting parallel to the axis of the range. This has enabled, in each case, an insignificant stream to cut down a deep narrow canyon directly through the heart of the mountain block.

In the Sandia-Manzano block the bisection is at the Tijeras canyon, where the faulting and relationships of the strata are very clearly disclosed. The displacement can not be less than 1,000 feet. The Tijeras fault extends far beyond the foot of the range, being marked by a con-

spicuous ridge in which the beds stand on end. A geological section along the line of the canyon is represented below (figure 5):

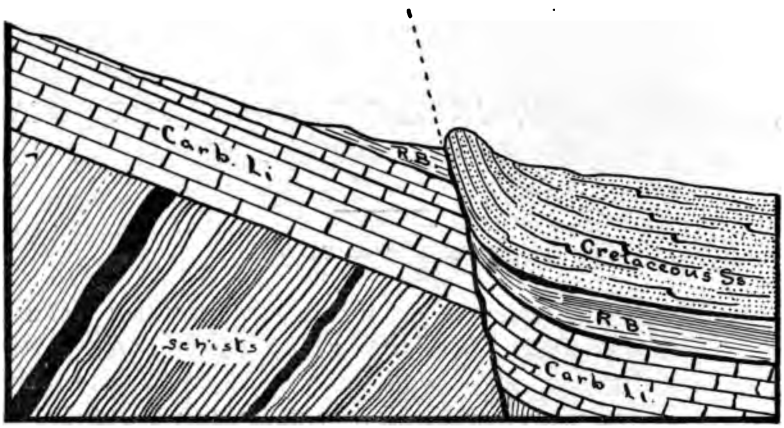


FIG. 5. Tijeras Canyon Fault. Displacement 1,000 feet.

In the Sierra de los Caballos range, 100 miles to the southward, the two parts of the mountain block are divided by the Palomas canyon—a narrow, deep cleft, the bottom of which is over two thousand feet below the crest of the ridge. The side of the canyon, where the latter makes a sharp bend, is represented as in figure 6.

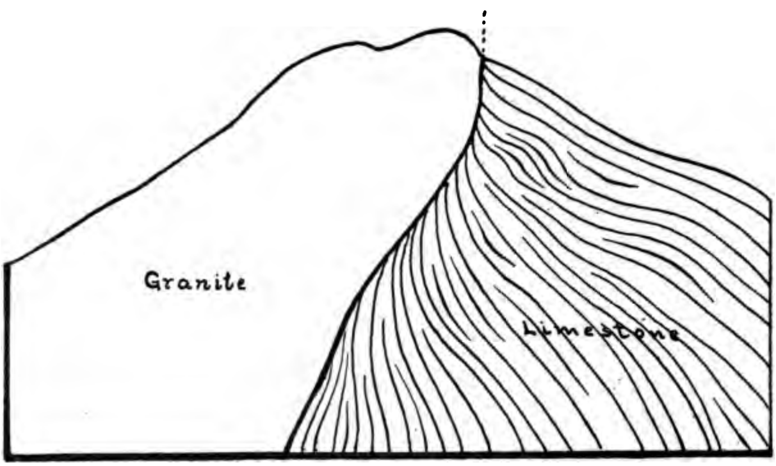


FIG. 6. Palomas Canyon Fault. Displacement 2,000 feet.

The Sierra Oscura-San Andreas range presents some features which are quite different from those already mentioned, which may be partly due to faulting at the time the blocks were tilted. The two parts of the range overlap somewhat, and dip in opposite directions. The major fault plane along which the block was upraised lies on different sides of the two parts of the range. Between the two parts is a flat plain, several miles wide, which, however, is considerably elevated above the plains on either side of the great ridge. The mountains are capped by Carboniferous limestones; so also is the small plain between. The section appears to be as follows (figure 7):

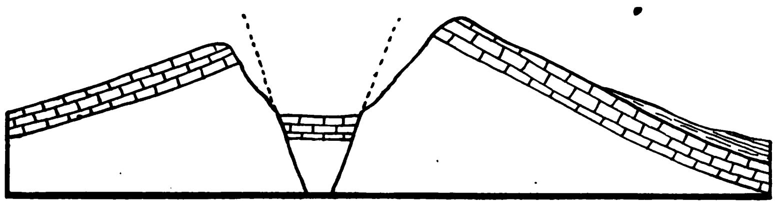


FIG. 7. Fault Block between the Sierra Oscura and San Andreas Range Displacement 2,500 feet.

GEOLOGICAL STRUCTURE OF THE JORNADA DEL MUERTO AND ADJOINING BOLSÓN PLAINS.

BY CHARLES R. KEYES.

The recent visits of a number of the members of the Academy to the Tulerosa district and contiguous plains in New Mexico makes it seem worth while to call attention to some of the major geologic structures of the region.

The section represented below is in an east and west direction through the station of Engle on the Atchison, Topeka & Sante Fe railroad, reaching beyond Alamagordo on the El Paso & Northeastern railroad.

The section shows for the Jornada plain a simple synclinal structure, with profound faults on the opposite side of the marginal mountain ranges in either direction.

On the Rio Grande side of the Caballos range repeated faulting is indicated—the river occupying the minor fault-blocks next the great fault-block of the main mountain ridge.

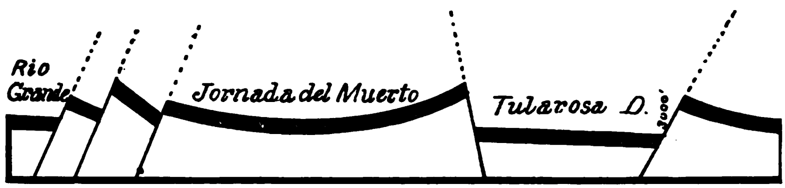


FIG. 8. Geological Structure of Jornada and Tularosa Deserts.

The highest part of the Caballos exhibits very clearly the evidences of a profound thrust-plane the geological age of which greatly antedates the period of normal block faulting which gives the present characteristic aspects to the region. The Carboniferous limestones for a distance of three-fourths of the distance to the summit of the range stand nearly vertically. Erosion has bevelled the stratification planes at angles of about 35 degrees—the slope of the eastern side of the range. This imparts to all except the upper part of the mountain face a remarkably contorted appearance, with horizontal beds of the same composition capping the summit. The effect is almost inexplicable until the position of the thrust-fault is recognized.

Immediately east of the western rim of the bolson and between the Sierras de los Caballos and Fra Cristobal are a number of small lava cones 300 to 400 feet high, each of which send out a basaltic flow for several miles in all directions from its center. These basalt flows appear to cover some of the earlier mesa gravels. They are quite recent—probably early Pleistocene in age.

The gentle syncline of the Jornada is perhaps its most characteristic structural feature. It is to be noted, however, that this region is not a simple trough but a syncline which has experienced repeated, or rather continued, upturning

of its margins while the process of general base leveling was going on.

In the San Andreas range there is found a simple monoclinal block. The profound faulting is on the eastern flank of the range. From the foot extends another broad bolson plain extending to the foot of the lofty Sierra Blanca.

The faults represented indicate displacements of 3,000 to 5,000 feet.

NORTHWARD EXTENSION OF THE LAKE VALLEY LIMESTONE.

BY CHARLES R. KEYES.

As a terranal name Lake Valley is applied to a remarkable blue limestone occurring at the famous silver mining camp of the same title, situated in Sierra county, New Mexico. The formation is noteworthy for the reason that it carries the typical Lower Burlington fauna of Iowa. On this account it is of special interest to Iowa geologists.

The first recognition of the Lower Burlington fauna, a thousand miles away from the original locality, is due to Mr. Frank Springer, a former Iowan, and the leading authority on American crinoids.*

At Lake Valley the limestone bearing that name is, as at Burlington, crinoidal in character. Mr. Springer, in the article cited, furnished a considerable list of crinoids as well as of other fossils, all of which are the most characteristic forms of the Lower Burlington limestone of southeastern Iowa. Since the appearance of the paper mentioned, twenty years ago, no further reference has ever been made to the Burlington fauna in southwestern United States.

*Am. Jour. Sci. (3), Vol. XXVII, pp. 97-108, 1884.

Lake Valley is in the southwest part of New Mexi
That its limestone is a geological formation of considera
geographic extent has been recently demonstrated by t
finding of the same fauna in localities many miles fr
the original location in Sierra county. Of special inter
is the fact of the recent discovery of the Lower Burling
fossils, such typical forms as *Batocrinus subæqualis* (Ha
in the Magdalena range, more than 100 miles north
Lake Valley.

Singularly enough, in New Mexico the earliest Carb
iferous strata appear to be followed by the latest terra
of that age—the great median section of the Mississi
valley being seemingly absent. In other words, the Lo
Burlington appears to be followed by beds carrying
faunas of the Upper Missourian series of the Mississi
valley.

The vertical sequence of the Carboniferous rocks
Magdalena mountains in central New Mexico is essentia
as follows:

CARBONIFEROUS SECTION IN MAGDALENA MOUNTAINS.

		FEET.
13.	Limestone, blue, heavily bedded with thick shale partings	300
12.	Shale, sandy, greenish	200
11.	Sandstone, greenish, micaceous, soft	50
10.	Sandstone, quartzitic, pebbly	60
9.	Shale, dark colored, silicious	50
8.	Limestone, gray, crinoidal	45
7.	Upper Vein.	
6.	Limestone, gray, heavily bedded, crinoidal	30
5.	Limestone, blue, impure, fine-grained, siliceous, "Silver Pipe Lime"	8
4.	Silver Pipe Vein.	
3.	Limestone, gray, subcrystalline	60
2.	Contact Vein.	
1.	Schist, granite and greenstones, over	1,000

The early Carboniferous rocks are believed to extend
No. 9 of the section; while all above is late Carbonifer
It is a noteworthy coincident that the Lower Carboni

ous rocks of New Mexico are the formations in which occur extensive lead deposits just as they are in the Mississippi Valley.

In New Mexico there are no coal-bearing terranes of Carboniferous age. Extensive deposits of bituminous coal, anthracite, and lignite occur in the New Mexican Cretaceous formations which are upwards of 7,000 feet in thickness. In this connection it may be mentioned that the coal deposits of New Mexico are more extensive than those of the whole of the Mississippi Valley.

Extensive beds carrying the Lower Burlington fauna also have been found recently in the San Andreas range and in the Sierra Oscura in east-central New Mexico, seventy-five miles east of Lake Valley.

From these statements it may be inferred that the Lower Burlington faunas will be found very widely distributed in the southwest—probably over all the southwestern half of New Mexico, extending on into Arizona and northern Mexico.

GROWTH AND PIGMENT PRODUCTION OF PSEUDOMONAS JANTHINA.

BY HARRY F. WATT.

The study here presented was undertaken to determine the growth characters of *Pseudomonas janthina* and the relations between color production and composition of medium.

The culture used was derived from the water of a farm well in northwestern Iowa. From its morphology and growth characters it was determined to be *Pseudomonas janthina* (Zopf.) Chester.

MORPHOLOGY.—Bacillus, 0.5 to 0.8 x 1.5 to 5 microns, ends rounded, motile by means of one or two polar flagellæ. Stains well using Gram's method. No spore production, stains readily with ordinary analine dyes.

CULTURAL CHARACTERS, *Gelatin Plates.*—Colonies appear first as small yellowish, or whitish dots, liquefying the the gelatin, and eventually with greenish purple centers and violet borders. Microscopically fragmental, grumose.

Gelatin Stab.—Gelatin liquefied after some time, growth at first whitish, becoming violet.

Agar Slant.—Growth smooth, spreading, thin at first and whitish yellow, soon becoming deep violet or even violet black and very much crumpled, tough.

Potato.—Growth on the potato at first whitish or whitish yellow, soon developing small purple points.

Bouillon.—At first turbid, but soon developing a membrane at first whitish, soon turning violet.

Milk.—Milk not coagulated, upper portion violet.

PHYSIOLOGICAL CHARACTERS.—In the cultivation on the above media great variations in color production were

noticed. Cultures growing under seemingly identical conditions in some cases produced very little, if any, color, in other cases producing a large amount. An effort was made to determine the cause, or some of the causes of this variation.

Effect of the Acidity and Alkalinity of the Culture Medium.—To test tubes containing 10c.c. of bouillon, varying amounts of normal hydrochloric acid, and sodium hydrate were added, i.e., $\frac{1}{80}$ c.c., $\frac{1}{40}$ c.c., $\frac{3}{80}$ c.c., $\frac{1}{20}$ c.c., $\frac{1}{10}$ c.c., and by tenths of c.c., up to nine-tenths c.c. These together with neutral bouillion were inoculated with this organism. The limits of growth were found to lie between 0.1c.c. sodium hydrate, and a little less than 0.1c.c. of normal hodrochloric acid, the maximum at about $\frac{3}{80}$ c.c. hydrochloric acid. The organism is quite sensitive in the variations of the reactions of the medium in which it is grown, but reaches its maximum development in a medium which is very slightly acid. The amount of growth in all cases and the amount of color produced were similar. In no case was there growth without color production.

Effect of Sunlight.—Agar slants of the organism, freshly inoculated, were exposed to the direct rays of the sun for periods ranging from five minutes to four hours. In no case could any difference be detected between the growth of cultures so exposed, and those which were kept in a dark chamber. The organism seems to be unusually resistant to the antiseptic properties of light.

The Relation of Free Oxygen to Growth and Color Production.—The absence of oxygen practically prevents the growth of the organism, and no color, therefore, is produced.

Effect of Variations in the Composition of Medium on the Growth and Color Production.—Various solutions and media were tested to determine, if possible, what were the sources of carbon and nitrogen that would produce the maximum growth and production of color.

As a basis for these solutions the Stickstoffreie Mineralische Nährlösung (M. nährlösung) of Meyer* was used.

*Arthur Meyer. Mikrokopisches Practicum. II. 15.

KH_2PO_4, 1.00 g., $CaCl_2$, 1.00 g., $MgSO_4+7H_2O$, 0.3 g., NaCl, 0.1 g., Fe_2Cl_6, .01 g., Water, 1000 g. The various solutions made from this and their effect upon the growth and color production of this organism are given below.

Dextrose, 0.5 g., cane sugar, 0.5 g., glycerin, 0.5 g., M. nährlösung, 100.00 g. A very slight membranous sediment was formed.

Potassium nitrate, 1.0 g., dextrose, 1.0 g., M. nährlösung, 100 g. Slight growth but no color was produced.

Potassium nitrate, 1.0 g., glycerin, 1.0 g., M. nährlösung, 100 g. Some growth, but no color.

Potassium nitrate, 1.0 g., cane sugar, 0.5 g., glycerin, 1.0 g., M. nährlösung, 100 g. Decided growth, but no color. It seems that this organism is capable of using its nitrogen in the form of nitrates, but can not produce color.

Ammonium chloride, 1.0 g., dextrose, 1.0 g., M. nährlösung, 100 g. Slight sediment, whitish, granular, no color.

Ammonium chloride, 1.0 g., cane sugar, 0.5 g., glycerin, 0.5 g., M. nährlösung, 100 g. Some sediment, whitish granular, more than in the preceding.

Ammonium tartrate, 1.0 g., glycerin, 1.0 g., cane sugar, 0.5 g., M. nährlösung, 100 g., cloudy, granulated, whitish, sediment, no color.

Ammonium tartrate, 1.0 g., dextrose, 1.0 g., M. nährlösung, 100 g. Cloudy, granulated, white sediment, rather more than in the preceding.

Asparagin, 0.2 g., $MgSO_4$, 0.1 g., K_2HPO_4, 0.1 g. Good growth, and decided color produced on the surface.

Asparagin, 1.0 g., K_2HPO_4, 0.1 g., $MgSO_4$, 0.1 g., glycerin, 2.0 g. Good growth, large amount of color on the suface. The medium below the surface had a decided green tinge. This is to be noted in a large number of solutions in which asparagin was used.

Asparagin, 1.0 g., M. nährlösung, 100 g. Slight purple scum, white sediment, decided green tinge.

Asparagin, 1.0 g., dextrose, 3.0 g., M. nährlösung, 100 g. A heavy purple scum and membranous white growth

throughout. At first there was a slight green tinge, but this soon disappeared.

Asparagin, 1.0 g., glycerin, 1.0 g., M. nährlösung 1.00 g., white membranous growth, tinged with purple at the top. Medium with a decided greenish tinge.

Asparagin, 1.0 g., glycerin, 1.0 g., cane sugar, 0.5 g., M. nährlösung, 100 g. A light purple scum, white membranous growth at the base of tube, medium with a green tinge.

As above noted the presence of asparagin is favorable to growth When this organism is grown in a medium containing asparagin, the green tinge is almost invariably present. The color is very similar to that which appears when an alcoholic solution of the violet coloring matter is treated with a solution of sodium hydrate.

Peptone, 1.0 g., cane sugar, 1.0 g., water, 100 g. Light purple scum, considerable light sediment.

Peptone, 1.0 g., beef extract, 1.0 g., cane sugar, 1.0 g., water, 100 g. A very heavy, dark, almost black, purple scum, thick and decidedly wrinkled, was formed. The maximum amount of growth and color obtained, was had in this medium.

Peptone, 1.0 g. beef extract, 1.0 g., dextrose, 1.0 g., water, 100 g. The growth similar to the preceding.

Peptone, 1.0 g., dextrose, 1.0 g., water, 100 g. Color production somewhat less than in the preceding. Beef extract seems to be very favorable to color production.

Peptone, 1.0 g., ammonium sulphate, 1.0 g., potassium nitrate, 1.0 g., M. nährlösung, 500 g. Purple scum similar to the preceding is formed.

Arrowroot Starch was also used as a medium. This is an almost pure starch containing very little proteid. Growth was slight on slant, but well colored.

Potato.—On the potato the growth was not so luxuriant as that which has been described by various authors. It is generally stated that the growth is luxuriant and spreading. In this study it formed a brownish, or yellowish white, glistening, raised growth, which in the course of

time, became spotted here and there with small violet spots.

Rice Flour.—There was a better growth and greater production of color on the rice flour than on any of the other solid media used. The growth is spreading, dark purple, thick at first, and becoming very much wrinkled.

Blood Serum.—Growth good.

Egg Albumen.—Coagulated albumen of egg was also tested and proved to be excellent as a culture medium. Growth very thick and heavy.

Pigment.—The purple pigment is soluble in alcohol, but not in ether, chloroform or xylol. The results obtained by *Schneider were checked as follows: The addition of ammonia changes the color to a blue or blue-green, as is the case when sodium hydrate is added. The addition of normal hydrochloric acid decolorizes the solution. When the solution is evaporated to dryness and the purple residue is treated with sulphuric acid a yellow solution is formed.

A strong alcoholic solution when allowed to stand for a period of three weeks, tightly corked, was found to have lost its purple color and to have become almost transparent, but with a reddish-brown tinge. This solution, when treated with acids and alkalies, bahaved as did the original purple solution.

*Die Bedentung der Bakterienfarbstoffe. Separatabdruck aus den Arbeiten des Bakterial. Instits der Grossh. Hochschule zu Karlsruhe. 25.

*THE SYNTHESIS OF ETHYL ALCOHOL FROM ACETYLENE.

BY J. C. FRAZEE.

Synopsis:

Introduction.

Ethyl Alcohol, its ordinary formation and physical properties.

Acetylene and its properties. Its formation from calcium carbide.

$CaC_2 + H_2O = C_2H_2 + CaO$ ....(1), or

$CaC_2 + 2H_2O = C_2H_2 + Ca(OH)_2$ ....(2).

Syntheses.

1. $C_2H_2 + 2H = C_2H_4$ ....(3).
   $C_2H_4 + H_2SO_4 = C_2H_5\ HSO_4$ ....(5).
   $C_2H_5\ HSO_4 + H_2O = \underline{C_2H_5OH} + H_2SO_4$ .... (6).
2. $C_2H_2 + 4H = C_2H_6$ ....(4).
   $C_2H_6 + 2Cl = C_2H_5Cl + HCl$ ....(7).
   $C_2H_5Cl + KOH = \underline{C_2H_5OH} + KCl$ ....(10).
3. $C_2H_2 + H_2O = C_2H_4O$ ....(12).
   $C_2H_4O + 2H = \underline{C_2H_5OH}$ ....(13).
4. $C_2H_2 + 2HI = C_2H_4I_2$ ....(18).
   $C_2H_4I_2 + PbO = C_2H_4O + PbI_2$ ....(20).
   $C_2H_4O + 2H = \underline{C_2H_5OH}$ ....(13).

Conclusion.

Ethyl alcohol, the alcohol most generally used in commerce, is prepared on a technical scale almost exclusively

* This paper was omitted from Volume XI on account of lack of space.

by what is termed the "spirituous fermentation" of saccharine juices. These juices occur in many plants and fruits and belong, in chemical classification, to the carbohydrates, which may be arranged into the following classes:

1. Glucoses, or Monoses, having the formula $C_6H_{12}O_6$. Grape sugar and fruit sugar are the more important representatives of this class.

2. Saccharobioses, with the formula $C_{12}H_{22}O_{11}$, whose chief sugars are malt sugar, cane sugar, and milk sugar.

3. Polysaccharides, whose formula is $(C_6H_{10}O_5)x$. Starch and dextrine constitute the more important members of this class.

The simple sugars of the formula $C_6H_{12}O_6$ are capable of direct alcoholic fermentation. This is especially true of grape sugars and of fruit sugars, as well as of most sugars among the saccharobioses. Commercially, it is of the greatest importance that the saccharobioses and polysaccharides, which are not directly fermentable, may be converted by water absorption into directly fermentable sugars and these then fermented.

Absolutely pure ethyl alcohol is a mobile, colorless liquid with an agreeable odor. It boils at 78.3° and has a specific gravity of 0.80625 at 0°. At -90°, it assumes the appearance of a thick liquid, and at -130°, it solidifies to a white mass. It burns with a non-luminous flame and absorbs water energetically from the air.

The passing from an inorganic to an organic compound, without the intervention of Nature, was considered an impossibility by chemists, until 1828, when Wöhler synthesized urea from isocyanate of ammonium. Since that time many organic compounds have been made in the laboratory, some of which have not as yet been discovered in nature. A very familiar illustration of this transition is found in the production of acetylene from calcium carbide, the equation of the reaction being:

$$CaC_2 + H_2O = \underline{C_2H_2} + CaO \ldots\ldots (1), \text{ or}$$

$$CaC_2 + 2H_2O = C_2H_2 + Ca(OH)_2 \ldots\ldots (2).$$

Since the improvements in the electric furnace have rendered the manufacture of calcium carbide commercially practicable, the attention of chemists has been directed somewhat to the manufacture of the higher organic compounds from acetylene. The synthesis of ethyl alcohol, especially, has been the goal towards which they have striven. This has been accomplished in a variety of ways, but none of them has produced the final product so cheaply as the old fermentation process, and a practical commercial method has yet to be discovered.

Acetylene, whose formula is C_2H_2, was first observed by Edmund Davy. Berthelot introduced the name "acetylene" and studied the gas carefully. It belongs to the subdivision of the hydrocarbons having the general name Acetylenes or Alkines and the formula $C_n H_{2n-2}$. It is therefore an unsaturated compound. Pure acetylene is a gas of ethereal odor. It may be liquified at $+1°$, under a pressure of forty-eight atmospheres. It solidifies when rapidly vaporized and then melts at $-81°$. It is very slightly soluble in water, but in alcohol and ether it will dissolve to some extent. It burns with a smoky flame, and with nine volumes of air, or two and one-half volumes of oxygen, forms an exceedingly explosive mixture.

The chief impurities in acetylene made from commercial calcium carbide are hydrogen sulphide and hydrogen phosphene. It may be freed from these in the following ways:

1. By passing the gas through an acid solution of copper sulphate and then through a solution of chromic acid.
2. By passing it through porous chloride of lime.
3. By washing it with a solution of bromine water.

The amount of acetylene evolved from calcium carbide is not so great as one would expect, only five hundred feet of the gas being liberated from one hundred pounds of calcium carbide. It is partially due to this fact that no process of making ethyl alcohol from acetylene has as yet been successful.

In thinking of possible methods in the synthesis in hand perhaps the one first suggesting itself would be as follows.

It is well known that platinum black has the peculiar property of causing hydrogen to unite with other gases, without being itself changed. Among the hydrocarbons, those thus affected are, in general, only the unsaturated ones.

Acetylene may be structurally represented thus:— $\begin{array}{l} C - H. \\ \Vert\!| \\ C - H. \end{array}$

It will be noticed that there are three bonds uniting the two atoms of carbon. Until but one bond remains in this position, the compound will be an unsaturated one. If acetylene and hydrogen are passed together over platinum black, one of the bonds, uniting the two carbon atoms, is broken, exposing two free bonds, thus: $\begin{array}{l} -C - H \\ \;\;\Vert \\ -C - H. \end{array}$ One atom of hydrogen now unites with each of the free bonds forming $\begin{array}{l} H - C - H \\ \quad\;\Vert \\ H - C - H, \end{array}$ or C_2H_4. The equation of this reaction is:

$$C_2H_2 + 2H = C_2H_4 \ldots . (3).$$

C_2H_4 is a gas called ethylene, or olefiant gas, olefiant meaning " oil forming." It will be noted that this is also an unsaturated compound. A part of it will, therefore, suffer further transposition, though all of the ethylene, in the majority of cases, may not be so changed. The transformation will be analagous to that of acetylene and the product will be $\begin{array}{c} H \\ | \\ H-C-H \\ | \\ H-C-H, \\ | \\ H \end{array}$ or C_2H_6, called ethane, the equation of the reaction being:

$$C_2H_4 + 2H = C_2H_6 \ldots . (4)$$

This is a saturated compound and belongs to what is called the "limit hydrocarbons," because no more hydrogen can be added to it without decomposing it.

It is possible that some of the acetylene and some of the hydrogen may pass through unchanged. In this case, the final product may contain ethane, ethylene, acetylene, and hydrogen.

It has been discovered that concentrated sulphuric acid will absorb ethylene very slowly at ordinary temperatures, but completely at 174°. Ethane, acetylene and hydrogen are, however, unaffected and will, therefore, separate themselves from the ethylene when they are conducted through the heated acid. When ethylene is absorbed by the sulphuric acid, it unites with it chemically, forming what is known as ethyl sulphuric acid The equation of the reaction is:

$$C_2H_4+\genfrac{}{}{0pt}{}{H}{H}SO_4=\genfrac{}{}{0pt}{}{C_2H_5}{H}SO_4\ldots.(5)$$

The solution is now cooled to the ordinary temperature diluted with water and boiled. The reaction will give ethyl alcohol and sulphuric acid, the alcohol being distilled off and condensed. The equation of this reaction is:

$$C_2\genfrac{}{}{0pt}{}{H_5}{H}SO_4+H_2O=C_2H_5OH+H_2SO_4\ldots.(6).$$

If the sulphuric acid is not concentrated at the end of this reaction, the water may be driven off by heat and the reconcentrated acid used over again.

The alcohol thus made has some advantages in purity over the product obtained by fermentation, which often contains some wood alcohol and traces of higher alcohols sometimes grouped under the name of "fusel oil." In order to eliminate these as nearly as possible the alcohol is filtered through charcoal, which, however, tends to create a new impurity—i. e., acetaldehyde. On the other hand, if the process is rightly conducted, the chance of anything besides ethyl alcohol and sulphuric acid being evolved, in equation (6), may be reduced to a minimum and an alcohol of greater purity, therefore, may be obtained from calcium carbide than from grain.

When the gases ethane, acetylene, and hydrogen separate themselves from the sulphuric acid, as described above, they should be conducted through an ammoniacal solution of cuprous chloride, where all of the acetylene will be absorbed, forming a red precipitate having the formula: $HC \equiv CCu.\, Cl\, Cu$. Ethane and hydrogen are not affected by this solution and will therefore pass off in gaseous form and be separated from the acetylene. The ethane and hydrogen are now treated with chlorine gas in diffused sunlight, the following reaction taking place:

$$C_2H_6+H+3Cl=C_2H_5Cl+2HCl \ldots (7).$$

C_2H_5Cl is called ethyl chloride. It is an ethereal liquid, boiling at 12.5°, and having a specific gravity of 0.921 at 0°.

It has been found that if ethyl chloride is boiled with water in a sealed tube, the chlorine will slowly leave the ethyl chloride to form hydrochloric acid with one of the atoms of hydrogen in the water, the remaining atom of hydrogen and the atom of oxygen replacing the chlorine in the ethyl chloride. The equation of this reaction is:

$$C_2H_5Cl+H_2O=C_2H_5OH+HCl \ldots (8).$$

This, however, is a very tedious process. A reaction of the same nature, but of more ease and quickness of accomplishment, may be obtained by substituting potassium or sodium hydroxide in the place of the water. It will be remembered that there is some hydrochloric acid mixed with the ethyl chloride. This will, however, not interfere with the desired reaction, but will simply require a greater amount of the caustic alkali than if the ethyl chloride alone were present. The first reaction will be between the hydrochloric acid and the alkali, and will continue as long as free hydrochloric acid remains. It will act according to this equation:

$$HCl+KOH=KCl+H_2O \ldots (9).$$

When entire neutralization has been effected, a second reaction will take place, thus:

$$C_2H_5Cl+(KCl+H_2O)+KOH=\underline{C_2H_5OH}+2\,KCl+H_2O \ldots (10).$$

We have now made alcohol from acetylene in two ways:

1. By converting it to ethylene; this to ethyl sulphuric acid; and this to ethyl alcohol, and,

2. By converting the acetylene to ethane; then to ethyl chloride; and then to alcohol.

Before taking up a third synthesis, it may be of interest to consider briefly the red precipitate HC≡C Cu. Cl Cu. obtained from the action of acetylene on the ammoniacal solution of cuprous chloride. It is an exceedingly unstable compound. If it is heated to 100°, it will explode violently; or, if it is dry, as slight a disturbance as touching it with a feather will sometimes cause it to decompose with an explosion. If it is treated with hydrochloric acid, the acetylene will be released in a chemically pure state. This is one of the best methods of obtaining chemically pure acetylene. The reaction is given in the following equation:

$$HC{\equiv}C\ Cu.\ Cl\ Cu. + HCl = C_2H_2 + 2\ CuCl \ldots.(11).$$

We shall now proceed to the consideration of a third synthesis, which is perhaps more nearly practical than any other yet devised. It is unique in that no reagents are consumed, which is a very extraordinary occurrence in a set of complicated reactions.

It is known that acetylene is practically insoluble in water. If it were soluble, and if as it dissolved, it united chemically with the water, the reaction would be according to this equation.

$$C_2H_2 + H_2O = C_2H_4O \ldots.(12).$$

The C_2H_4O being acetaldehyde, which, it will be noticed, is a very near approach to ethyl alcohol, being different from it only by containing two atoms less of hydrogen, which, if they could be added to acetaldehyde would give a reaction as represented in this equation:

$$C_2H_4O + 2\ H = \underline{C_2H_5OH} \ldots.(13).$$

The equations, though so apparently simple, are extremely difficult to effect properly, there being a tendency toward the formation of by-products. The follow-

ing is as good a method for the accomplishing of the reactions as is known, and, when viewed from the commercial standpoint, has some very practical features inasmuch as it consumes no reagents, as has been stated,

It has been found possible to effect the reaction represented in equation (12) by what is technically known as a "katalyctic" reaction. Katalysis is the name of a class of chemical reactions which occur in the presence of some other chemical, which is itself unaffected. It is supposed that, if given sufficient time, the reaction would take place without assistance, but for some unexplained reason, it is greatly hastened by the presence of the katalyctic. Two instances of these reactions have already been given—i. e., the union of hydrogen and acetylene or ethylene in the presence of platinum black; and the action of chlorine gas upon ethane in diffused sunlight.

The katalyctic best adapted to aid in the union of water with acetylene is mercuric bromide. Mercuric chloride is of the same nature as mercuric bromide in rendering the reaction possible, but is unfitted for practical use, because of the fact that a part of it undergoes a reaction with the acetylene and is precipitated as a white, non-explosive powder, having the formula $C_2(HgCl)_2$.

The method of procedure in the use of mercuric bromide is as follows: The salt is put into water in excess, it being only moderately soluble, and the solution heated to about 35°. The acetylene is then conducted into the solution, being liberated near the bottom of the vessel containing it, thus giving more time for reaction before it can reach the surface and escape. There should be some means by which the liquid shall be kept in constant agitation to prevent the insulation of the acetylene from the water by the acetaldehyde that is formed. As acetaldehyde volatilizes at 20.8° it will leave the solution almost as rapidly as it is formed, especially if as high a temperature as 35° is maintained. The acetaldehyde vapor is now carried through a condenser, at about 0°, so arranged that should there be any free acetylene, it may escape, while the con-

densed acetaldehyde is conducted into a receptacle whose temperature should remain below 18°.

Acetaldehyde is a mobile, peculiar smelling liquid. The odor is very penetrating and resembles that of apples slightly. It has a specific gravity of 0.8009 at 0°. It is miscible in all proportions with water, ether, and alcohol. It was given the name "aldehyde," meaning dehydrated alcohol, by Liebig. It has the property of polymerization to a marked degree. It is this property that presents one of the greatest difficulties, which must be surmounted in the synthesis we are considering. The following are some of the ways in which polymerization may occur. Small quantities of acids or salts, especially zinc chloride and sodium acetate convert aldehyde at ordinary temperatures into paraldehyde which has the formula $(C_2H_4O)_3$, the change, accomplished with the evolution of heat and contraction, is particularly rapid if a few drops of sulphuric acid are present. Paraldehyde is a colorless liquid boiling at 124°, and having a specific gravity of 0.9943 at 20°. It has the very peculiar property of being more soluble in cold water than in warm. It is used in medicine as a sleep-producer. When distilled with sulphuric acid ordinary aldehyde is regenerated.

Metaldehyde is produced by the same reagents as those producing foraldehyde, but the temperature is kept below 0°. It is a white, crystalline body insoluble in water, but readily dissolved by hot alcohol and ether. If heated to 112°–115°, it sublimes, without previously melting, and passes into ordinary aldehyde with only slight decomposition.

The water in the solution of mercuric bromide, previously mentioned, will be carried off, after having united with the acetylene, as acetaldehyde. The mercuric bromide will remain unchanged. It is therefore necessary to add water from time to time and the evolution of acetaldehyde will continue as long as the acetylene is conducted into the solution.

The next problem is to convert the aldehyde into ethyl alcohol. Equation (13) represents the requisite reaction. It is impossible to simply lead the hydrogen gas into the acetaldehyde and make it unite chemically with it to form alcohol. The hydrogen must be in the nascent state,–i. e., the condition in which it is after it is first evolved and before it has formed into atoms. It is the ionic state.

When sodium or potassium are placed in water, they liberate nascent hydrogen and form the caustic alkalis thus:

$$K+H_2O=H+KOH....(14).$$

The hydrogen, liberated in this way, however, is evolved so rapidly as to be unfit for application in a chemical reaction. The potassium is first united with metallic mercury to form what is called potassium amalgam, and this is used in place of the metallic potassium. Potassium amalgam may be formed by simply bringing the potassium into contact with the mercury. The reaction evolves a great deal of heat and the product is a solid resembling zinc in appearance. When potassium amalgam is placed in water, the reaction is very slow, the particles of hydrogen being so broken up as to give the solution a milky appearance. The same reaction takes place as represented in equation (14), and the mercury is left in the metallic state at the bottom of the solution.

In order to apply the reaction to the acetaldehyde, the aldehyde is diluted freely with water and the mixture then treated with the potassium amalgam. The reaction is that expressed in equation (13) and the product is ethyl alcohol.

Two reactions tending to form by-products, at this stage, must be guarded against. The caustic alkali, which forms during the reaction, has a marked tendency to polymerize the acetaldehyde; and the potassium will, if proper precautions are not taken, decompose the alcohol formed, liberate hydrogen from it, and unite with the alcohol radical to form potassium alcoholate. The most nearly effective means of preventing these side reactions is to have an excess of water, which will eliminate the forma-

tion of alcoholate and tend to decrease the polymerization of the aldehyde by making the solution of caustic alkali more dilute and consequently less active. The solution should also be kept at as high a temperature as it may be without causing the aldehyde to vaporize, because the polymerization of the aldehyde is more likely to occur at low temperatures. The greater the excess of water, the higher may the temperature of the solution be raised without liberating the aldehyde. When the action has been completed, the alcohol may be distilled off.

If the potassium amalgam were to be formed each time from metallic potassium, the process just outlined would be highly impractical, because of the cost of the potassium. However, the entire amount of potassium amalgam consumed in the above reaction may be very simply recovered each time and used over and over again for an indefinite length of time. The process is this: After the solution containing the alcohol has had all the alcohol distilled from it, it is boiled down till the solution of potassium hydroxide is a supersaturated one, and will remain so during the reaction which is to follow. The positive pole of an electric circuit is now placed in the metallic mercury and the negative pole is immersed in the solution of potassium hydroxide. The current in passing through the solution will again unite the potassium with the mercury. The amalgam will have no tendency to decompose as long as the solution of potassium hydroxide remains concentrated. In this way the cost of metallic sodium or potassium may be entirely ignored.

Another method of combining acetylene and water to form aldehyde is to run acetylene gas into moderately dilute sulphuric acid, which has had its temperature raised to about 100°, cooling the solution to the ordinary temperature and diluting with water. The solution is then distilled when acetaldehyde will be given off in greater or less amount. This is, however, a very unsatisfactory method, because of the formation of by-products, the chief

of which is crotonaldehyde, having the formula C_4H_6O. The equations of this side-reaction are:

$$2C_2H_4O=CH_3CH\ OH\ CH_2CHO\ldots.(15).$$

This product is called aldol. It suffers further change, the sulphuric acid extracting a molecule of water from it and leaving crotonaldehyde, thus:

$$CH_3CH\ OH\ CH_2CHO=CH_3CH\ CH\ CHO+H_2O\ldots.(16).$$

Some di-oxy-butane, or butylene alcohol, may also be formed.

Acetaldehyde may also be converted into ethyl alcohol by the action of glacial acetic acid on zinc which evolves hydrogen according to the reaction shown in this equation:

$$Zn+2HC_2H_3O_2=2H+Zn\,(C_2H_3O_2)_2\ldots.(17).$$

The formation of zinc acetate is, however, detrimental to the formation of alcohol, causing the acetaldehyde to polymerize in the same way that it was affected by the solution of potassium hydroxide.

Another method of synthesis, differing considerably from those which have been described, may be called the "halogen substitution process." Iodine is, perhaps, the best member of the halogen group to use in this reaction, because of its stability, but bromine may be used in place of it. Chlorine does not yield such satisfactory results, and fluorine, because of the tendency of its acid to dissolve glass, is the least desirable of all.

The halogen used is obtained in its acid form. In the present discussion, hydriodic acid will be taken as the representative. It has been found that, if acetylene is conducted into hydriodic acid, the acid will unite with the acetylene directly in the ratio of two parts of hydriodic acid to one of the acetylene. The equation of the union is:

$$C_2H_2+2\,HI=C_2H_4I_2\ldots.(18).$$

This is a complete chemical reaction and not merely a physical union. The acetylene has entirely lost its identity, as may be proved by treating the product of the

reaction represented in equation (18) with nascent hydrogen, the reaction being according to this equation:

$$C_2H_4I_2+4H=C_2H_6+2HI....(19).$$

Here we recognize ethane, which is a saturated compound. As the hydrogen has substituted itself in place of the iodine, instead of merely adding itself to the compound, we have definite proof that the product formed by the reaction expressed by equation (18) is also a saturated compound, differing entirely from acetylene in its chemical nature and composition.

$C_2H_4I_2$ is called ethylene iodide. It is a solid melting at 81°. It is now treated with lead monoxide at 130° temperature when a chemical reaction is effected in which the iodine and oxygen exchange places and acetaldelyde is evolved. The reaction is represented by this equation:

$$C_2H_4I_2+PbO=C_2H_4O+PbI_2....(20).$$

The acetaldehyde may now be converted to ethyl alcohol by one of the methods previously described.

If the lead iodide, resulting from the reaction expressed in equation (20), is submitted to an intense heat, the iodine will be liberated and may be recovered and reconverted into hydriodic acid. The lead will remain behind in the form of lead monoxide and may be used over again, the cost of iodine need not, therefore, be considered in these reactions.

It has been found that acetylene in contact with a solution of caustic potash and air, changes in the presence of diffused sunlight to acetic acid, which has the formula HC_2H_3O. The reaction is probably represented thus:

$$C_2H_2+O+H_2O+(KOH)=(KOH)+HC_2H_3O_2....(21).$$

There would be a reaction, however, between the potassium hydroxide and acetic acid which would result in potassium aectate and water, thus:

$$KOH+HC_2H_3O_2=KC_2H_3O_2+H_2O....(22).$$

The acetic acid could be recovered by treating the potassium acetate with some mineral acid thus:

$$KC_2H_3O_2+HCl=KCl+HC_2H_3O_2 \ldots . (23).$$

It will be noticed that acetic acid is closely related to alcohol. In fact, when fruit ferments and sours, there is at first alcohol present and afterwards acetic acid.

It has been the object of this paper to point out the facts known at the present time in regard to the representative reactions by which calcium carbide, an inorganic compound, may be converted into ethyl alcohol, one of the most important of the organic compounds. None of the methods outlined are of commercial value, as the cheapest one can not produce alcohol at less than four times the cost of the product derived from fermentation. Neither is it at all probable that a method of manufacture, which will yield the product at a lower cost, will be worked out, because of the fact that there is practically no expense for reagents in some of the processes outlined.

Heat and electric power might be procured very cheaply for a manufacturing plant, by locating it where advantage might be taken of water power, such as is found at Niagara, and yet we could not apply our equations, which work out so nicely, and be attended with anything but financial loss.

THE FLOWERING PLANTS OF HARDIN COUNTY.

BY MORTON E. PECK.

The following list of the flowering plants of Hardin county is mainly the result of three seasons of observation and collection. Only a small portion of each season, however, has been allotted to field work, and the greater part of this has been confined to the northern half of the territory, with only occasional visits to other sections; the list, therefore, is doubtless far from complete. Were it not that circumstances render it impossible, another season would be given to its preparation, and the result would be far more satisfactory.

Hardin county has a somewhat diversified topography, with an abundance of morainic hills, a fair proportion of high woodland along the Iowa river, and occasional small tracts of prairie that have never been plowed, on account of the stony and sterile nature of the soil. There is but a scant area of sandy and alluvial land, and no considerable lakes or ponds. The drainage is imperfect, owing to the irregularity of the glacial deposits, so that swampy tracts are common. Most of the foregoing facts might almost be inferred from a perusal of the list with the brief notes on the distribution and habitat of the several species.

Thanks are due to Prof. L. H. Pammel for the determination of several difficult forms.

A LIST OF THE FLOWERING PLANTS OF HARDIN COUNTY, IOWA.

PINACEÆ.

PINUS.

1. *P. strobus* L. Bluffs along the Iowa river near Steamboat rock.

JUNIPERUS.

2. *J. virginiana* L. Mostly on high, rocky banks of the Iowa river.

TAXACEÆ.

TAXUS.

3. *T. minor* (Michx.) Brit. (*T. canadensis* Willd.) High, rocky woods and river banks. Common.

TYPHACEÆ.

TYPHA.

4. *T. latifolia* L. Abundant in swamps.

SPARGANIACEÆ.

SPARGANIUM.

5. *S. eurycarpum* Eng. Common in swamps.
6. *S. androcladium* (Eng) Morong. (*S. simplex androcladium* Eng.) Shallow ponds and swamps. Frequent.

NAIADACEÆ.

POTAMOGETON.

7. *P. lonchites* Tuck. (*P. fluitans* Roth.) Common in streams.
8. *P. heterophyllus* Schreb. Frequent in ponds.
9. *P. pusillus* L. Common in swamps and ponds.

NAIAS.

10. *N. flexilis* (Willd.) Rost & Schm. Swamps; apparently not common.

ALISMACEÆ.

ALISMA.

11. *A. plantago-aquatica* L. (*A. plantago* L.) Abundant everywhere in wet ground.

SAGITTARIA.

12. *S. latifolia* Willd. (*S. variabilis* Eng.) Abundant in swamps and wet ground.
13. *S. rigida* Pursh. (*S. heterophylla rigida* Eng.) Frequent near ponds and swamps.

GRAMINEÆ.

ANDROPOGON.

14. *A. scoparius* Michx. Common in dry uncultivated and unpastured ground.
15. *A. furcatus* Muhl. Same habitat as the preceding; common.

CHRYSOPOGON.

16. *C. avenaceus* (Michx.) Benth. Same habitat as the two preceding; common.

SYNTHERISMA.

17. *S. sanguinalis* (L.) Nash. (*Panicum sanguinale* L.) Common, especially in cultivated ground.
18. *S. linearis* (Krock.) Nash. (*Panicum glabrum* Gaudin.) An abundant and troublesome weed in lawns, gardens and waste ground.

PANICUM.

19. *P. crus-galli* L. Abundant in moist ground, especially about buildings.
20. *P. porterianum* Nash. (*P. latifolium* Walt.) Frequent in woods.
21. *P. xanthophysum* A. Gr. Dry, open ground; infrequent.
22. *P. scribnerianum* Nash. (*P. scoparium* Wats.) Dry open ground; frequent.
23. *P. pubescens* Lam. (*P. dichotomum* L.—apparently; which species, as limited by Britton, has the culm and leaves nearly glabrous and does not occur as

far north as our territory.) Prairies and dry woods; abundant.

24. *P. depauperatum* Muhl. Dry prairies; common.
25. *P. virgatum* L. Mostly in dry, uncultivated ground; common.
26. *P. proliferum* Lam. Moist ground; common.
27. *P. capillare* L. Common everywhere.

IXOPHORUS.

28. *I. verticillatus* (L.) Nash. (*Setaria verticillata* Beauv.) Along streets and roads and in cultivated ground; local, but apparently increasing.
29. *I. glaucus* (L.) Nash. (*S. glauca* Beauv.) Abundant everywhere.
30. *I. italicus* (L.) Nash. (*S. italica* Kunth.) Occasional in waste ground.

CENCHRUS.

31. *C. tribuloides* L. Common in sandy localities, but not generally distributed.

ZIZANIA.

32. *Z. aquatica* L. Shallow water of the Iowa river; not common.

HOMALOCENCHRUS.

33. *H. virginicus* (Willd.) Brit. (*Leersia virginica* Willd.) Common in wet, shady localities.
34. *H. oryzoides* (L.) Poll. (*L. oryzoides* L.) Common in swampy ground.

PHALARIS.

35. *P. arundinacea* L. Frequent in moist soil.

SAVASTINA.

36. *S. odorata* (L.) Scrib. (*Heirochloe borealis* Roem. and Schultes.) Frequent in moist meadows.

ARISTIDA.

37. *A. basiramea* Eng. Dry prairies; infrequent.

STIPA.

38. *S. spartea* Trin. Dry prairies and meadows; common.

MUHLENBERGIA.

39. *M. mexicana* (L.) Trin. Damp, usually shady situations; common.

40. *M. racemosa* (Michx.) B. S. P. (*M. glomerata* Trin.) Moist or sometimes dry, open ground; common.

41. *M. sylvatica* Torr. Shady banks; frequent.

42. *M. diffusa* Schreb. Dry, mostly shady ground; frequent.

PHLEUM.

43. *P. pratense* L. Common.

ALOPECURUS.

44. *A. geniculatus* L. Low meadows; infrequent.

SPOROBOLUS.

45. *S. longifolius* (Torr.) Wood. Dry prairies; scarce.

46. *S. vaginæflorus* (Torr.) Wood. (*S. minor* Vasey.) Frequent in dry, waste places.

47. *S. cuspidatus* (Torr.) Wood. Dry, waste or sterile ground; common.

48. *S. heterolepis* A. Gr. Dry prairies; common.

CINNA.

49. *C. arundinacea* L. Frequent in damp woods.

AGROSTIS.

50. *A. alba* L. Abundant in moist meadows.

51. *A. perennans* (Walt.) Tuck. Common in woods and along streams.

52. *A. hyemalis* (Walt.) B. S. P. (*A. scabra* Willd.) Common in fields and waste ground.

CALAMAGROSTIS.

53. *C. canadensis* (Michx.) Beauv. Wet meadows and swamps; common.

SPARTINA.

54. *S. cynosuroides* (L.) Willd. Common in swamps and wet meadows.

BOUTELOUA.

55. *B. hirsuta* Lag. Frequent on dry, sterile knolls.

56. *B. curtipendula* (Michx.) Torr. (*B. racemosa* Lag.) Common in dry, open ground.

PHRAGMITES.

57. *P. phragmites* (L.) Karst. (*P. communis* Trin.) Common in swamps.

ERAGROSTIS.

58. *E. purshii* Schrad. Abundant in dry, waste ground

59. *E. major* Host. Cultivated and waste ground abundant.

60. *E. hypnoides* (Lam.) B. S. P. (*E. reptans* Nees.) Muddy banks of streams; frequent.

EATONIA.

61. *E. obtusata* (Michx.) Gray. Frequent in dry soil.

KŒLERIA.

62. *K. cristata* (L.) Pers. Common in dry, sterile soil.

MELICA.

63. *M. mutica* Walt. Frequent in moist, open or shady ground.

DACTYLIS.

64. *D. glomerata* L. Roadsides and waste ground; scarce.

POA.

65. *P. annua* L. Abundant in somewhat moist and shady situations.

66. *P. compressa* L. With the following, but preferring rather dry ground; common.

67. *P. pratensis* L. Almost universal.

PANICULARIA.

68. *P. nervata* (Willd) Kuntze (*Glyceria nervata* Trin.) Abundant in wet ground.

69. *P. fluitans* (L) Kuntze (*G. fluitans* R. Br.) Common in swamps and shallow ponds.

FESTUCA.

70. *F. octoflora* Walt. (*F. tenella* Willd.) Abundant in dry, sterile ground.

71. *F. elatior* L. Roadsides and waste places; infrequent.
72. *F. nutans* Willd. Abundant in dry woods.

BROMUS.

73. *B. ciliatus* L. Frequent in woods.
74. *B. kalmii* Gray. Dry, open woods; scarce.
75. *B. secalinus* L. Fields and waste ground; infrequent.

AGROPYRON.

76. *A. repens* (L.) Beauv. Roadsides and waste grounds; common.
77. *A. repens glaucum* (Desf.) Scribn. Common, especially along railroads.
78. *A. tenerum* Vasey. Roadsides; infrequent.

HORDEUM.

79. *H. jubatum* L. An abundant and troublesome weed.

ELYMUS.

80. *E. striatus* Willd. Common in woods.
81. *E. virginicus* L. Common in low ground along streams and roadsides.
82. *E. canadensis* L. Abundant in meadows and waste ground. The variety *glaucifolius* Gr. is found infrequently along streams.

HYSTRIX.

83. *H. hystrix* (L.) Millsp. (*Asprella hystrix* Willd.) Common in woods.

CYPERACEÆ.

CYPERUS.

84. *C. flavescens* L. Common in wet ground.
85. *C. rivularis* Kunth. (*C. diandrus castaneus* Torr.) Along streams; infrequent.
86. *C. inflexus* Muhl. (*C. aristatus* Rottb.) Wet, sandy ground along streams; frequent.
87. *C. esculentus* L. Moist fields; abundant.
88. *C. strigosus* L. Moist, open woods and along streams; common. Our specimens seem to be mostly the variety *robustior* Kunth.

ELEOCHARIS.

89. *E. palustris* (L.) R. & S. Ponds and swamps; frequent.

90. E. *acicularis* (L.) R. & S. Abundant in wet ground.

91. *E. intermedia* (Muhl.) Schultes. Borders of ponds and swamps; abundant.

SCIRPUS.

92. *S. lacustris* L. Swamps and streams; abundant.

93. *S. fluviatilis* (Torr.) Gray. Swamps; common.

94. *S. atrovirens* Muhl. Swamps and along streams; abundant.

ERIOPHORUM.

95. *E. polystachyon* L. Wet meadows; frequent.

HEMICARPHA.

96. *H. micrantha* (Vahl.) Brit. (*H. subsquarrosa* Nees.) Muddy banks of streams; infrequent.

CAREX.

97. *C. lupulina* Muhl. Swampy woods; scarce.

98. *C. lupulina bella-villa* (Dew.) Bail. With the type; the two forms are quite different in appearance, but intergrade perfectly.

99. *C. monile* Tuck. Common in bogs and wet meadows.

100. *C. hystricina* Muhl. Wet ground, meadows or open woods; frequent.

101. *C. pseudo-cyperus* L. Swampy ground; infrequent.

102. *C. comosa* Boott. (*C. pseudo-cyperus americana* Hochst.) Shallow muddy ponds; scarce.

103. *C. trichocarpa* Muhl. Frequent in swamps and wet meadows. The species appears to be exceedingly variable. Our specimens are tall and very slender, with narrow, loosely flowered spikes and large perigynia; very different in every way from the following.

104. *C. aristata* R. Br. (*C. trichocarpa aristata* Bail.) Common in swamps.

105. *C. lanuginosa* Michx. (*C. filiformis latifolia* Boeck.) Frequent in swampy meadows.

106. *C. fusca* All. Low meadows; infrequent.
107. *C. stricta* Lam. Abundant in bogs, low meadows, and along streams.
108. *C. stricta angustata* (Boott.) Bail. Ditches near railroad; frequent.
109. *C. davisii* Schw. & Torr. Moist woods; infrequent.
110. *C. longirostris* Torr. Common in damp woods.
111. *C. assiniboinensis* Boott. A single colony, growing in a moist thicket; apparently quite typical. Culms long, slender and nearly prostrate. Abundantly stoloniferous in late summer, the stolons four feet in length.
112. *C. tetanica* Schk. Frequent in wet woods.
113. *C. meadii* Dew. (*C. tetanica meadii* Bail.) Wet meadows; frequent.
114. *C. laxiflora blanda* (Dew.) Boott. (*C. laxiflora striatula* Carey). Common in wet woods.
115. *C. laxiflora various* Bail. With the preceding; common.
116. *C. albursina* Sheld. (*C. laxiflora latifolia* Boott.) Deep, moist woods; scarce. Wholly unlike any of the forms of *C. laxiflora* found in our territory.
117. *C. laxiculmis* Schwein. Wet ground along streams; frequent. Our material differs from the type in having the pistillate spike linear, three to five times as long as wide, and the perigynia scarcely angled and abruptly tipped with a short but distinct entire beak, which is either straight or slightly curved outward.
118. *C. setifolia* (Dew.) Brit. (*C. eburnea* Boott.) Frequent on dry cliffs along the Iowa river.
119. *C. pennsylvanica* Lam. Dry woods and prairies; abundant.
120. *C. pubescens* Muhl. Common in woods.
121. *C. stipata* Muhl. Swampy ground; frequent.
122. *C. teretiuscula* Gooden. Wet meadows and bogs; frequent.

123. *C. vulpinoidea* Michx. Wet ground; abundant.
124. *C. xanthocarpa* Bick. Meadows; scarce. Not quite typical, as the perigynia are dark brown and distinctly nerved.
125. *C. sartwellii* Dew. Wet meadows and bogs; frequent.
126. *C. rosea* Schk. Common in woods and thickets.
127. *C. sparganioides* Muhl .High woods; infrequent.
128. *C. scoparia* Schk. ' Dry, open ground; common.
129. *C. cristatella* Brit. (*C. tribuloides cristata* Bail.) Meadows; frequent.
130. *C. festucacea* Willd. (*C. straminea brevior* Dew.) Meadows and thickets; frequent.

ARACEÆ.

ARISÆMA.

131. *A. triphyllum* (L.) Torr. Woods; common.
132. *A. dracontium* (L.) Schott. Moist woods; frequent.

ACORUS.

133. *A. calamus* L. Common in swamps.

LEMNACEÆ.

SPIRODELA.

134. *S. polyrhiza* (L.) Schleid. Common in ponds.

LEMNA.

135. *L. trisulca* L. Common, with the preceding.

COMMELINACEÆ.

TRADESCANTIA.

136. *T. virginica* L. Common in waste ground.

PONTEDERIACEÆ.

PONTEDERIA.

137. *P. cordata* L. Borders of ponds; local.

HETERANTHERA.

138. *H. dubia* (Jacq.) MacM. (*H. graminea* Vahl.) Ponds and muddy shores; infrequent.

JUNCACEÆ.

JUNCUS.

139. *J. tenuis* Willd. Fields and waste ground; abundant.
140. *J. nodosus* L. Moist open ground; frequent.
141. *J. torreyi* Cov. (*J. nodosus megacephalus* Tor.) Moist, open ground; frequent.
142. *J. canadensis* J. Gay. Moist, open ground; common.

MELANTHACEÆ.

ZYGADENUS.

143. *Z. elegans* Pursh. Common in damp meadows; less frequently a form occurs on dry hills.

UVULARIA.

144. *U. grandiflora* Smith. Woods; common.

LILIACEÆ.

ALLIUM.

145. *A. tricoccum* Ait. Deep woods; common.
146. *A. canadense* L. Meadows and waste ground; common.

LILIUM.

147. *L. philadelphicum*. Frequent in meadows.
148. *L. canadense* L. Moist woods and meadows; infrequent.

ERYTHRONIUM.

149. *E. albidum* Nutt. Common in damp woods.

CONVALLARIACEÆ.

ASPARAGUS.

150. *A. officinalis* L. Well established and common in woods, meadows and waste ground.

VAGNERA.

151. *V. racemosa* (L.) Morong. (*Smilacina racemosa* Desf.) Frequent in woods and thickets.
152. *V. stellata* (L.) Morong. (*S. stellata* Desf.) Abundant in woods thickets and along streams.

UNIFOLIUM.

153. *U. canadense* (Desf.) Greene. (*Maianthemum canadense* Desf.) Rocky river banks; infrequent.

POLYGONATUM.

154. *P. biflorum* (Walt.) Ell. Common in woods.

155. *P. commutatum* (R. & S.) Dietr. (*P. gigantum* Dietr.) Common in thickets and meadows.

TRILLIUM.

156. *T. nivale* Ridd. High woods; common locally.

157. *T. erectum* L. Frequent in rich, damp woods.

SMILACEÆ.

SMILAX.

158. *S. herbacea* L. Common in thickets.

159. *S. ecirrhata* (Eng.) Wats. Abundant in woods and meadows.

160. *S. hispida* Muhl. Frequent in moist woods.

AMARYLLIDACEÆ.

HYPOXIS.

161. *H. hirsuta* (L.) Cov. (*H. erecta* L.) Moist meadows and dry banks; abundant.

DIOSCORIACEÆ.

DIOSCOREA.

162. *D. villosa* L. Common in woods and thickets.

IRIDACEÆ.

IRIS.

163. *I. versicolor* L. Common along streams and about swamps.

SISYRINCHIUM.

164. *S. angustifolium* Mill. Common in dry open ground.

ORCHIDACEÆ.

CYPRIPEDIUM.

165. *C. candidum* Willd. Frequent in wet meadows.

166. *C. hirsutum* Mill. (*C. pubescens* Willd.) Dry woods and thickets; infrequent.

ORCHIS.

167. *O. spectabilis* L. Moist woods; scarce.

HABENARIA.

168. *H. bracteata* (Willd.) R. Br. Dry, open ground; infrequent.

169. *H. leucophæa* (Nutt.) Gray. Damp meadows; frequent.

GYROSTACHYS.

170. *G. cernua* (L.) Kuntze. (*Spiranthes cernua* Rich.) Wet meadows; scarce.

JUGLANDACEÆ.

JUGLANS.

171. *J. nigra* L. Woods; common.

172. *J. cinerea* L. Woods; abundant.

HICORIA.

173. *H. minima* (Marsh.) Brit. (*Carya amara* Nutt.) Woods; abundant

174. *H. ovata* (Mill.) Brit. (*Carya alba* Nutt.) High woods; common. A hybrid between this and the preceding species occurs.

SALICACEÆ.

POPULUS.

175. *P. alba* L. Occasionally spreading along roadsides.

176. *P. balsamifera candicans* (Ait.) Gr. Sparingly escaped along roads.

177. *P. grandidentata* Michx. Frequent in woods.

178. *P. tremuloides* Michx. Common in woods.

179. *P. deltoides* Marsh. (*P. monilifera* Ait.) Common.

SALIX.

180. *S. nigra* Marsh. Common in wet ground.

181. *S. amygdaloides* Anders. Mostly along streams; frequent.

182. *S. alba vitellina* (L.) Koch. Rarely escaped.

183. *S. fluviatilis* Nutt. (*S. longifolia* Muhl.) Common along streams.

184. *S. humilis* Marsh. Frequent in dry open ground.
185. *S. discolor* Muhl. Wet meadows and banks of streams; common.
186. *S. sericea* Marsh. Along streams; frequent.
187. *S. petiolaris* Smith. Wet thickets and meadows; frequent.
188. *S. cordata* Muhl. Wet ground; common.

BETULACEÆ.

CARPINUS.

189. *C. caroliniana* Walt. Wooded hillsides and ravines; common locally.

OSTRYA.

190. *O. virginiana* (Mill.) Willd. High woods; common.

CORYLUS.

191. *C. americana* Walt. Abundant in dry, sparsely wooded localities.

BETULA.

192. *B. papyrifera* Marsh. Woods along the Iowa river, near Steamboat Rock and Eldora.

FAGACEÆ.

QUERCUS.

193. *Q. rubra* L. Woods; abundant.
194. *Q. alba* L. Dry woods; common.
195. *Q. macrocarpa* Michx. Woods; abundant.

ULMACEÆ.

ULMUS.

196. *U. americana* L. Abundant in low woods.
197. *U. fulva* Michx. Abundant in woods.

CELTIS.

198. *C. occidentalis* L. Common in woods.

MORACEÆ.

HUMULUS.

199. *H. lupulus* L. Thickets and waste ground; infrequent.

CANNABIS.

200. *C. sativa* L. Thickets, river banks and waste ground; common.

URTICACEÆ.

URTICA.

201. *U. gracilis* Ait. Damp ground; abundant.

URTICASTRUM.

202. *U. divaricatum* (L.) Kuntze. (*Laportea canadensis* Lindl.) Abundant in damp, shady ground.

ADICEA.

203. *A. pumila* (L.) Raf. (*Pilea pumila* Gray.) Shady places; abundant.

BŒHMERIA.

204. *B. cylindrica* (L.) Willd. Moist ground; frequent.

PARIETARIA.

205. *P. pennsylvanica* Muhl. Moist, shady places; abundant.

SANTALACEÆ.

COMANDRA.

206. *C. umbellata* (L.) Nutt. Dry, open ground; common.

ARISTOLOHIACEÆ.

ASARUM.

207. *A. canadense* L. Common in moist woods.

POLYGONACEÆ.

RUMEX.

208. *R. acetosella* L. Dry, sterile ground; common.

209. *R. verticillatus* L. Swamps and shallow ponds; frequent.

210. *R. altissimus* Wood. Damp, open ground; common.

211. *R. patientia* L. Moist ground; rare.

212. *R. britannica* L. Common in swamps.

213. *R. crispus* L. Waste places, especially in moist ground; abundant.

214. *R. obtusifolius* L. Waste ground; rare.
215. *R. persicarioides* L. Damp fields and along streams; scarce.

FAGOPYRUM.

216. *F. fagopyrum* (L.) Karst. (*F. esculentum* Moench,) Waste ground; infrequent and not long persistent.

POLYGONUM.

217. *P. amphibium* L. Ponds and swamps; frequent.
218. *P. hartwrightii* Gray. Low ground; infrequent.
219. *P. emersum* (Michx.) Brit. (*P. muhlenbergii* Wats.) In swamps and along streams; common.
220. *P. incarnatum* Ell. (*P. lapathifolium incarnatum* Wats.) Damp fields and waste ground; common.
221. *P. pennsylvanicum* L. Abundant in moist, cultivated ground.
222. *P. persicaria* L. Abundant in fields and waste ground.
223. *P. hydropiper* L. Abundant in swampy ground and wet fields.
224. *P. punctatum* Ell. (*P. acre* H. B. K.) With the preceding, but less abundant.
225. *P. orientale* L. Rarely escaped.
226. *P. virginianum* L. Frequent in damp, shady ground.
227. *P. aviculare* L. Abundant about houses and in waste ground.
228. *P. erectum* L. Common in waste ground.
229. *P. tenue* Michx. Dry, sterile ground; scarce.
230. *P. convolvulus* L, Abundant in fields and waste ground.
231. *P. scandens* L. (*P. dumetorum scandens* Gray.) Thickets and low river banks; common,

CHENOPODIACEÆ.

CHENOPODIUM.

232. *C. album* L. Cultivated and waste ground; abundant.

233. *C. boscianum* Moq. Shady places; common.
234. *C. hybridum* L. Common in waste ground.

CYCLOLOMA.

235. *C. atriplicifolium* (Spreng.) Coult. (*C. platyphyllum* Moq.) Wet, sandy ground near railroad; the only locality.

SALSOLA.

236. *S. tragus* L. (*S. kali tragus* Moq.) Waste ground along railroad; scarcely more than holds its own.

AMARANTHACEÆ.

AMARANTHUS.

237. *A. retroflexus* L. Abundant in cultivated and waste ground.
238. *A. hybridus* L. (*A. chlorostachys* L.) Frequent in moist ground; especially along streams.
239. *A. blitoides* Wats. Common in waste and cultivated ground.
240. *A. græcizans* L. (*A. albus* L.) Common in fields and waste ground.

NYCTAGINACEÆ.

ALLONIA.

241. *A. nyctaginea* Michx. (*Oxybaphus nyctagineus* Sweet). Common along railroads.
242. *A. hirsuta* Pursh. (*B. hirsutus* Choisy.) Common on dry prairies.

AIZOACEÆ.

MOLLUGO.

243. *M. verticillata* L. Along railroads and in waste sandy ground; frequent.

PORTULACACEÆ.

CLAYTONIA.

244. *C. virginica* L. Moist woods; common.

PORTULACA.

245. *P. oleracea* L. Abundant in cultivated ground.

CARYOPHYLLACEÆ.

AGROSTEMMA.

246. *A. githago* L. (*Lychnis githago* Scop.) Common in grain fields.

SILENE.

247. *S. stellata* (L.) Art. Common in woods and thickets.

248. *S. antirrhina* L. Common in waste sterile ground.

LYCHNIS.

249. *L. alba* Mill. (*L. vespertina* Sibth.) Becoming frequent along the streets of Iowa Falls.

SAPONARIA.

250. *S. officinalis* L. Common locally.

ALSINE.

251. *A. media* L. (*Stellaria media* Smith). Recently became very abundant about Iowa Falls, often forming a turf in shady lawns.

252. *A. longifolia* (Muhl.) Brit. (*S. longifolia* Muhl.) Swampy ground; frequent.

CERASTIUM.

253. *C. vulgatum* L. Moist, mostly shady ground; abundant during the past few years.

MŒHRINGIA.

254. *M. lateriflora* (L.) Feuzl. (*Arenaria lateriflora* L.) Common in dry woods.

ANYCHIA.

255. *A. canadensis* (L.) B. S. P. (*A. capillacea* DC.) Dry woods; scarce.

NYMPHÆACEÆ.

NYMPHÆA.

256. *N. advena* Soland. (*Nuphar advena* Ait. f.) Frequent in ponds.

CASTALIA.

257. *C. odorata* (Dry.) Woodv. and Wood. (*Nymphæa odorata* Ait.) Frequent in pools and swamps.

CERATOPHYLLACEÆ.

CERATOPHYLLUM.

258. *C. demersum* L. Ponds and swamps; frequent.

RANUNCULACEÆ.

CALTHA.

259. *C. palustris* L. Common in bogs and wet meadows.

ISOPYRUM.

260. *I. biternatum* (Raf.) T. & G. Frequent in moist woods.

ACTÆA.

261. *A. rubra* (Ait.) Willd. (*A. spicata rubra* Willd.) Common in woods.

AQUILEGIA.

262. *A. canadensis* L. Rocky woods and high river banks; common.

DELPHINIUM.

263. *D. carolinianum* Walt. (*D. azureum* Michx.) Dry hills and prairies; common.

ANEMONE.

264. *A. caroliniana* Walt. Prairies; frequent.
265. *A. cylindrica* Gray. Dry, open ground; frequent.
266. *A. virginiana* L. Woods; frequent.
267. *A. canadensis* L. (*A. pennsylvanica* L.) Damp open ground; common.

HEPATICA.

268. *H. acuta* (Pursh.) Brit. (*H. acutiloba* DC.) Cold woods; common.

SYNDESMON.

269. *S. thalictroides* (L.) Hoffmg. (*Ammonilla thalictroides* Spach.) High woods; common locally.

PULSATILLA.

270. *P. hirsutissima* (Pursh.) Brit. (*Anemone patens nuttalliana* Gray.) Still frequent on dry prairies but becoming scarcer each year.

CLEMATIS.

271. *C. virginiana* L. Frequent in thickets and along roads.

272. *C. viorna* L. Borders of fields; scarce.

RANUNCULUS.

273. *R. delphinifolius* Torr. (*R. multifidus* Pursh.) Frequent in swamps and slow streams. The variety *terrestris* Gr. is also found.

274. *R. ovalis* Raf. (*R. rhomboideus* Gold.) Dry prairies; frequent.

275. *R. abortivus* L. Dry or moist ground; abundant.

276. *R. septentrionalis* Poir. Abundant in damp ground.

277. *R. fasicularis* Muhl. Abundant in dry open ground.

THALICTRUM.

278. *T. purpurascens* L. Dry open woods; scarce.

279. *T. polygamum* Muhl. Damp meadows; abundant.

BERBERIDACEÆ.

BERBERIS.

280. *B. vulgaris* L. Open ground; scarce.

CAULOPHYLLUM.

281. *C. thalictroides* (L.) Michx. Rich woods; common.

PODOPHYLLUM.

282. *P. peltatum* L. Rich woods; common.

MENISPERMACEÆ.

MENISPERMUM.

283. *M. canadense* L. Prairies and borders of woods; common.

PAPAVERACEÆ.

SANGUINARIA.

284. *S. canadensis* L. Abundant in rich woods.

BICUCULLA.

285. *B. cucullaria* (L.) Millsp. (*Dicentra cucullaria* DC.) Common on wooded slopes.

ADLUMIA.

286. *A. fungosa* (Ait.) Greene. (*A. cirrhosa* Raf.) Escaped from the cemetery at Iowa Falls and more than holding its own.

CAPNOIDES.

287. *C. aureum* (Willd.) Kuntze. (*Corydalis aurea* Willd.) Common in waste ground.

CRUCIFERÆ.

THELYPODIUM.

288. *T. integrifolium* (Nutt.) Endl. Low woods; infrequent.

LEPIDIUM.

289. *L. virginicum* L. Abundant in waste ground.
290. *L. apetalum* Willd. (*L. intermedium* Gray) With the preceding, but less common.
291. *L. sativum* L. Rarely escaped.

THLASPI.

292. *T. arvense* L. Along railroads; rare.

SISYMBRIUM.

293. *S. officinale* (L.) Scop. Abundant about houses and in open woods.
294. *S. altissimum* L. Common along railroads.

SINAPIS.

295. *S. alba* L. (*Brassica alba* Boiss.) Rarely escaped.

BRASSICA.

296. *B. nigra* (L.) Koch. Abundant in waste and cultivated ground.
297. *B. arvensis* (L.) B. S. P. (*B. sinapistrum* Boiss). Abundant; but less so than the preceding.

RAPHANUS.

298. *R. sativus* L. Persisting about gardens for several years.

RORIPA.

299. *R. palustris* (L.) Bess. (*Nasturtium palustre* DC.). Abundant in swampy ground and wet fields.

300. *R. nasturtium* (L.) Rusby. (*N. officinale* R. Br.) In springs; infrequent.

301. *R. armoracia* (L.) Hitch. (*N. armoracia* R. Br.) Frequently escaped.

CARDAMINE.

302. *C. pennsylvanica* Muhl. Common along streams and in low ground.

303. *C. bulbosa* (Schreb.) B. S. P. (*C. rhomboidea* DC.) Abundant in wet meadows and along streams.

DENTARIA.

304. *D. laciniata* Muhl. Common in rich woods.

BURSA.

305. *B. bursa pastoris* (L.) Brit. (*Capsella bursa pastoris* Moench.) Abundant.

DRABA.

306. *D. caroliniana* Walt. Dry and sandy waste places.

SOPHIA.

307. *S. incisa* (Engl.) Greene. Dry ground, especially along railroads; common.

ARABIS.

308. *A. dentata* T. & G. Wooded ravines; frequent.

309. *A. hirsuta* (L.) Scop. Dry, stony ground; common.

310. *A. laevigata* (Muhl.) Poir. Dry rocks of river banks; infrequent.

311. *A. canadensis* L. Dry woods; frequent.

312. *A. glabra* (L.) Benth. (*A. perfoliata* Lam.) Along railroads; scarce.

ERYSIMUM.

313. *E. cheiranthoides* L. On dry rocks of river banks; frequent.

CAPPARIDACEÆ.

CLEOME.

314. *C. spinosa* L. Waste ground; rarely escaped.

POLANISIA.

315. *P. trachyspermum* T. & G. Waste ground; scarce.

CRASSULACEÆ.

SEDUM.

316. *S. telephium* L. Rarely escaped.

PENTHORUM.

317. *P. sedoides* L. Abundant in wet ground along streams.

SAXIFRAGACEÆ.

SAXIFRAGA.

318. *S. pennsylvanica* L. Wet meadows; scarce.

HEUCHERA.

319. *H. hispida* Pursh. Dry, stony ground; common.

MITELLA.

320. *M. diphylla* M. Wooded ravines and shady banks; frequent.

PARNASSIA.

321. *P. caroliniana* Michx. Wet meadows and along streams; scarce.

GROSSULARIACEÆ.

RIBES.

322. *R. cynosbati* L. Mostly on rocky banks; common.
323. *R. gracile* Michx. Open woods; common.
324. *R. floridum* L'Her. Low ground along streams; common.

ROSACEÆ.

OPULASTER.

325. *O. opulifolius* (L.) Kuntze. (*Physocarpus opulifolius* Michx.) Rocky banks of streams; frequent.

SPIRAEA.

326. *S. salicifolia* L. Swampy meadows; common.

RUBUS.

327. *R. strigosus* Michx. Dry woods; frequent.

328. *R. occidentalis* L. Thickets and borders of woods; common.

329. *R. villosus* L. Woods and roadsides; frequent.

330. *R. canadensis* L. Woods; infrequent.

FRAGARIA.

331. *F. virginiana* Duchesne. Prairies, woods and waste ground; abundant.

332. *F. americana* (Port.) Brit. (*F. vesca americana* Port.) Cool, wooded slopes; common.

POTENTILLA.

333. *P. arguta* Pursh. Common in pastures and waste ground.

334. *P. monspeliensis* L. (*P. norvegica* L.) Cultivated and waste ground; abundant.

335. *P. anserina* L. A good sized colony in waste ground near a railroad.

336. *P. canadensis* L. Meadows and pastures; frequent.

GEUM.

337. *G. canadense* Jacq. (*G. album* Gmel.) Moist woods; abundant.

338. *G. strictum* Ait. Low meadows and roadsides; infrequent.

AGRIMONIA.

339. *A. mollis* (T. and G.) Brit. (*A. eupatoria* L.) Woods and thickets; common.

ROSA.

340. *R. arkansana* Port. Abundant.

POMACEÆ.

MALUS.

341. *M. ioensis* (Wood) Brit. Borders of woods and along streams; common.

AMELANCHIER.

342. *A. canadensis* (L.) Medic. Common on high rocky river banks and in dry woods.

343. *A. botryapium* (L. f.) DC. (*A. canadensis oblongifolia* T. & G.) Apparently confined to the margins of steep, rocky river banks, where it is common.

344. *A. rotundifolia* (Michx.) Roem. (*A. canadensis rotundifolia* T. & G.) With the preceding but infrequent. Though the species is of doubtful standing, it appears to be quite distinct in our territory, showing no sign of intergrading with the typical *A. canadensis.*

CRATÆGUS.

345. *C. crus-galli* L. Frequent in open woods.

346. *C. coccinea* L. Common in woods.

347. *C. macracantha* Lodd. (*C. coccinea macracantha* Dud.) Frequent in woods.

348. *C. mollis* (T. & G.) Schule. (*C. coccinea mollis* T. & G.) Abundant in open woods.

DRUPACEÆ.

PRUNUS.

349. *P. americana* Marsh. Common in woods and along roads.

350. *P. pennsylvanica* L. f. Dry open woods and thickets; frequent.

351. *P. virginiana* L. Common in dry woods.

352. *P. serotina* Ehrh. Frequent about the borders of woods and along roads.

CÆSALPINACEÆ.

CASSIA.

353. *C. chamæcrista* L. Dry, sandy soil; common.

GLEDITSIA.

354. *G. triacanthos* L. Woods; infrequent.

GYMNOCLADUS.

355. *G. dioica* (L.) Koch. (*G. canadensis* Lam.) Deep woods; infrequent.

PAPILIONACEÆ.

BAPTISIA.

356. *B. bracteata* Ell. (*B. leucophœa* Nutt.) Prairies and pastures; common.

357. *B. leucantha* T. & G. Borders of fields and roadsides; scarce.

CROTALARIA.

358. *C. sagittalis* L. Along streams; rare.

MEDICAGO.

359. *M. sativa* L. Sparingly escaped and not long persistent.

360. *M. lupulina* L. Becoming abundant in pastures and along roads.

MELILOTUS.

361. *M. alba* Desv. Abundant and troublesome, especially along roads.

362. *M. officinalis* (L.) Lam. With the preceding; frequent.

TRIFOLIUM.

363. *T. procumbens* L. Along roads and in pastures and waste ground; common during the past year or two.

364. *T. pratense* L. Common.

365. *T. hybridum* L. Meadows and roadsides; common.

366. *T. repens* L. Abundant.

PSORALEA.

367. *P. argophylla* Pursh. Prairie; common.

AMORPHA.

368. *A. fruticosa* L. Wet ground along streams; common.

369. *A. canescens* Pursh. Prairies; abundant.

KUHNISTERA.

370. *K. candida* (Willd.) Kuntze. (*Petalostemon candidus* Michx.) Prairies and waste ground; abundant.

371. *K. purpurea* (Nutt.) MacM. (*P. violaceus* Michx.) With the preceding; abundant.

372. *K. foliosa* (Gray.) Kuntze. (*P. foliosus* Gray.) An apparently well established colony in waste ground near a railroad.

ROBINIA.

373. *R. pseudacacia* L. Roadside thickets; frequent.

ASTRAGALUS.

374. *A. crassicarpus* Nutt. (*A. caryocarpus* Ker.) Abundant on dry prairies.

375. *A. carolinianus* L. (*A. canadensis* L.) Along streams and roadsides.

MEIBOMIA.

376. *M. grandiflora* (Walt.) Kuntze. (*Desmodium acuminatum* DC.) Dry woods; common.

377. *M. pauciflora* (Nutt.) Kuntze. (*D. pauciflorum* DC.) High woods; rare. Known from only one locality.

378. *M. illinoensis* (Gray) Kuntze. (*D. illinoensis* Gray.) Dry, open ground; infrequent.

379. *M. canadensis* (L.) Kuntze. (*D. canadense* DC.) Meadows and thickets; abundant.

LESPEDEZA.

380. *L. capitata* Michx. Meadows and waste ground; common.

381. *L. leptostachys* Eng. Meadows; infrequent.

VICIA.

382. *V. americana* Muhl. Meadows; abundant.

LATHYRUS.

383. *L. venosus* Muhl. Roadsides and thickets; common.

384. *L. palustris* L. Wet meadows; common.

385. *L. ochroleucus* Hook. Dry woods and thickets; infrequent.

FALCATA.

386. *F. comosa* (L.) Kuntze. (*Amphicarpœa monoica* Nutt.) Woods and thickets; abundant.

APIOS.

387. *A. apios* (L.) MacM. (*A. tuberosa* Moench.) Thickets along streams; frequent.

STROPHOSTYLES.

388. *S. helvola* (L) Britt. (*S. angulosa* Ell.) Sandy ground; scarce.

GERANIACEÆ.

GERANIUM.

389. *G. maculatum* L. Woods and thickets common.
390. *G. carolinianum* L. Sterile ground; scarce.
391. *G. pusillum* L. About houses; becoming frequent.
392. *G. molle* L. Waste ground; recently introduced.

OXALIDACEÆ.

OXALIS.

393. *O. violacea* L. Fields and open woods; abundant.
394. *O. stricta* L. (*O. corniculata stricta* Sav.) Woods, fields and waste ground; abundant.

LINACEÆ.

LINUM.

395. *L. usitatissimum* L. Occasionally escaped in waste ground.
396. *L. sulcatum* Ridcl. Dry, open ground; common.

RUTACEÆ.

XANTHOXYLUM.

397. *X. americanum* Mill. Common in woods.

POLYGALACEÆ.

POLYGALA.

398. *P. verticillata* L. Fields and waste ground; common.
399. *P. viridescens* L. Damp meadows; scarce.
400. *P. senega* L. Open, stony ground; frequent.

EUPHORBIACEÆ.

ACALYPHA.

401. *A. virginica* L. Abundant in woods and waste ground.

EUPHORBIA.

402. *E. glyptosperma* Eng. Dry, open grounds; frequent.

403. *E. maculata* L. Abundant in waste ground.

404. *E. nutans* Lag. (*E. prestii* Gurs.). Dry, sterile ground; abundant.

405. *E. corollata* L. Sandy fields and waste ground; frequent.

406. *E. marginata* Pursh. Rarely an escape.

407. *E. heterophylla* L. Stony, waste ground; infrequent.

408. *E. peplus* L. Waste ground; rare.

409. *E. cyparissias* L. Rarely escaped.

ANACARDIACEÆ

RHUS.

410. *R. glabra* L. Thickets and borders of woods; common.

411. *R. radicans* L. (*R. toxicodendron* L. ?) Woods thickets and roadsides; common.

CELASTRACEÆ.

EUONYMUS.

412. *E. atropurpureus* Jacq. Frequent in woods.

CELASTRUS.

413. *C. scandens* L. Woods and thickets; common.

STAPHYLEACEÆ.

STAPHYLEA.

414. *S. trifolia* L. Woods frequent.

ACERACEÆ.

ACER.

415. *A. saccharinum* L. (*A. dasycarpum* Ehrh.) Along streams; frequent.

416. *A. saccharum* Marsh. (*A. saccharinum* Wang.) High woods; common.

417. *A. negundo* L. (*Negundo aceroides* Moench.) Borders of woods; common.

BALSAMINACEÆ.

IMPATIENS.

418. *I. biflora* Walt. (*I. fulva* Nutt.) Swampy woods; abundant.

419. *I. aurea* Muhl. (*I. pallida* Nutt.) With the preceding; abundant.

RHAMNACEÆ.

CEANOTHUS.

420. *C. americanus* L. Meadows and thickets; common

421. *C. ovatus* Desf. Dry, stony ground; scarce.

VITACEÆ.

VITIS.

422. *V. labrusca* L. One specimen growing on dry ground.

423. *V. vulpina* L. (*V. riparia* Michx.) Woods and thickets; common.

PARTHENOCISSUS.

424. *P. quinquefolia* (L.) Planch. (*Ampelopsis quinquefolia* Michx.) In woods and on steep rocks; abundant.

TILIACEÆ.

TILIA.

425. *T. americana* L. Woods; abundant.

MALVACEÆ.

MALVA.

426. *M. rotundifolia* L. Common about houses and in gardens.

ABUTILON.

427. *A. abutilon* (L.) Rusby. (*A. avicennæ* Gautn.) Fields and waste ground; abundant.

HIBISCUS.

428. *H. trionum* L. Roadsides and about houses; infrequent.

HYPERICACEÆ.

HYPERICUM.

429. *H. ascyran* L. Banks of streams; scarce.
430. *H. sphærocarpum* Michx. Dry ground; infrequent.
431. *H. canadense* L. Wet ground; infrequent.
432. *H. mutilum* L. Wet, sandy ground; infrequent.

CISTACEÆ.

HELIANTHEMUM.

433. *H. canadense* (L.) Michx. Dry, sandy ground; common.

LECHEA.

434. *L. villosa* L. (*L. major* Michx.) With the preceding; common.

VIOLACEÆ

VIOLA.

435. *V. palmata* L. Open woods; infrequent.
436. *V. pedatifida* Don. Meadows and thickets; common.
437. *V. obliqua* Hill. (*V. palmata cucullata* Gray.) Abundant in woods and meadows.
438. *V. pedata* L. Dry prairies; common.
439. *V. pubescens* Ait. Abundant in moist woods.

LYTHRACEÆ.

LYTHRUM.

440. *L. alatum* Pursh. Abundant in wet ground.

ONOGRACEÆ

LUDWIGIA.

441. *L. polycarpa* Short & Peter. Frequent in swampy ground.

EPILOBIUM.

442. *E. lineare* Muhl. Swampy ground; frequent
443. *E. coloratum* Muhl. Swampy ground and along streams; abundant.
444. *E. adenocaulon* Haussk. Wet ground; rare.

ONAGRA.

445. *O. biennis* (L.) Scop. (*Oenothera biennis* L.) Meadows and waste ground; abundant.

ŒNOTHERA.

446. *Oe. laciniata* Hill. (*Oe. sinuata* L.) Dry, sandy ground. Two specimens obtained from different localities.

MERIOLIX.

447. *M. serrulata* (Nutt.) Walp. (*Oe. serrulata* Nutt.) Dry prairies; abundant.

GAURA.

448. *G. coccinea* Pursh. Dry, open ground; scarce.

CIRCÆA.

449. *C. luteiana* L. Common in cool, damp woods.

HALORAGIDACEÆ

MYRIOPHYLLUM.

450. *M. verticillatum* L. Ponds; infrequent.

ARALIACEÆ.

ARALIA.

451. *A. racemosa* L. High banks of streams; frequent

452. *A. nudicaulis* L. Rich woods; common.

PANAX.

453. *P. quinquefolium* L. (*Aralia quinquefolia* Decsne & Planch.) Rich woods; becoming scarce.

UMBELLIFERÆ.

OXYPOLIS.

454. *O. rigidus* (L.) Brit. (*Tiedemannia rigida* Coult. & Rose.) Swamps; common.

HERACLEUM.

455. *H. lanatum* Michx. Damp woods and thickets; common.

PASTINACA.

456. *P. sativa* L. Moist, open ground; common.

POLYTÆNIA.

457. *P. nuttallii* DC. Prairies; frequent.

THASPIUM.

458. *T. barbinode* (Michx.) Nutt. Damp woods. Infrequent.

AETHUSA.

459. *A. cynapium* L. Roadsides; infrequent.

ERYNGIUM.

460. *E. aquaticum* L. (*E. yuccæfolium* Michx.) Meadows; common.

SANICULA.

461. *S. marylandica* L. Woods; abundant.

PIMPINELLA.

462. *P. integerrima* (L.) Gray. Dry or stony ground; common.

WASHINGTONIA.

463. *W. claytoni* (Michx.) Brit. (*Osmorrhiza brevistylis* D C.) Abundant in woods.

SIUM.

464. *S. cicutæfolium* Gmel. Swamps; infrequent.

APIUM.

465. *A. petroselinum* L. Rarely escaped.

ZIZIA.

466. *Z. aurea* (L.) Koch. Woods and meadows; abundant.

CICUTA.

467. *C. maculata* L. Wet meadows and swamps; abundant.

DERINGA.

468. *D. canadensis* (L.) Kuntze. (*Cryptotænia canadensis* DC.) Abundant in woods.

CORNACEÆ.

CORNUS.

469. *C. circinata* L'Her. Rocky river banks; common.

470. *C. stolonifera* Michx. Low ground; frequent.
471. *C. candidissima* Marsh. (*C. paniculata* L'Her.) Thickets and roadsides; common.
472. *C. alternifolia* L. f. Rocky banks; frequent.

PYROLACEÆ.

PYROLA.

473. *P. elliptica* Nutt. High woods; infrequent.

MONOTROPACEÆ.

MONOTROPA.

474. *M. uniflora* L. Rich woods; infrequent.

PRIMULACEÆ.

PRIMULA.

475. *P. farinosa* L. Growing in moss a few feet above the water on a perpendicular cliff along the Iowa river at Iowa Falls.

ANDROSACE.

476. *A. occidentalis* Pursh. Common in waste, sterile ground.

STEIRONEMA.

477. *S. ciliatum* (L.) Raf. Damp woods and along streams; common.
478. *S. quadriflorum* (Sims.) Hitch. (*S. longifolium* Gray.) Common in wet meadows.

NAUMBURGIA.

479. *N. thyrsiflora* (L.) Duby. (*Lysimachia thyrsiflora* L.) Frequent in swamps.

DODECATHEON.

480. *D. meadia* L. Prairies; becoming scarce.

OLEACEÆ.

FRAXINUS.

481. *F. americana* L. Woods; common.
482. *F. lanceolata* Borck. (*F. viridis* Michx. f.) Damp woods; common.
483. *F. nigra* Marsh. (*F. sambucifolia* Lam.) Woods; abundant.

GENTIANACEÆ.

GENTIANA.

484. *G. quinquefolia occidentalis* (Gray) Hitch. (*G. quinqueflora occidentalis* Gray.) Borders of woods and thickets, mostly on dry ground; common.

485. *G. puberula* Michx. Prairie; frequent.

486. *G. andrewsii* Griseb. Wet meadows and along streams; infrequent.

487. *G. flavida* Gray. (*G. alba* Muhl.) Thickets and roadsides in moist ground; infrequent.

APOCYNACEÆ.

APOCYNUM.

488. *A. androsæmifolium* L. Dry thickets and roadsides, especially sandy ground; common.

489. *A. cannabinum* L. Moist fields and along streams; common.

ASCLEPIADACEÆ.

ASCLEPIAS.

490. *A. tuberosa* L. Dry, open ground; common.

491. *A. purpurascens* L. Thickets; scarce.

492. *A. incarnata* L. Swampy ground; common.

493. *A. sullivantii* Eng. Dry, sandy, open ground; scarce.

494. *A. syriaca* L. (*A. cornuti* Dec.) Fields and meadows; abundant.

495. *A. ovalifolia* Dec. Dry, stony or sandy ground; scarce.

496. *A. verticillata* L. Sandy, open ground; frequent.

ACERATES.

497. *A. viridiflora* (Raf.) Eat. Dry, open ground; frequent.

498. *A. lanuginosa* (Nutt.) Dec. Dry, sterile ground: rare.

CONVOLVULACEÆ.

IPOMŒA.

499. *I. purpurea* (L.) Roth. Sparingly escaped along roads.

CONVOLVULUS.

500. *C. sepium* L. Abundant in fields and meadows.

CUSCUTACEÆ.

CUSCUTA.

501. *C. arvensis* Bryrich. On species of *Leguminosæ;* infrequent.
502. *C. polygonorum* Eng. (*C. chlorocarpa* Eng.) Frequent on Polygonum and other weeds in low ground.
503. *C. cephalanthi* Eng. (*C. tenuiflora* Eng.) Common on various coarse weeds.
504. *C. paradoxa* Raf. (*C. glomerata* Choisy). Frequent on various coarse weeds and shrubs.

POLEMONIACEÆ.

PHLOX.

505. *P. paniculata* L. Rarely escaped.
506. *P. maculata* L. Frequent in swampy meadows.
507. *P. pilosa* L. Abundant in meadows.
508. *P. divaricata* L. Abundant in damp woods.

POLEMONIUM.

509. *P. reptans* L. Abundant in woods.

HYDROPHYLLACEÆ.

HYDROPHYLLUM.

510. *H. virginicum* L. Woods; abundant.
511. *H. appendiculatum* Michx. Woods; rare.

MACROCALYX.

512. *M. nyctelea* (L.) Kuntze. (*Ellisia nyctelea* L.) Moist, shady places; abundant.

BORAGINACEÆ.

LAPPULA.

513. *L. lappula* (L.) Karst. (*Echinospermum lappula* Lehm.) Becoming common in open woods and waste ground.

514. *L. virginiana* (L.) Greene. (*E. virginicum* Lehm.) Abundant in moist woods.

MERTENSIA.

515. *M. virginica* (L.) D C. Woods; scarce.

LITHOSPERMUM.

516. *L. latifolium* Michx. Woods; frequent.

517. *L. canescens* (Michx.) Lehm. Dry, open ground; common.

518. *L. angustifolium* Michx. Dry prairies; common.

ONOSMODIUM.

519. *O. molle* Michx. (*O. carolinianum molle* Gray.) Dry prairies and open woods; common.

VERBENACEÆ.

VERBENA.

520. *V. urticifolia* L. Abundant in open woods, pastures and waste ground.

521. *V. hastata* L. With the preceding; abundant.

522. *V. stricta* Vent. With the two preceding; abundant.

523. *V. bracteosa* Michx. Abundant in waste ground.

LABIATÆ.

TEUCRIUM.

524. *T. canadense* L. Abundant in wet ground.

ISANTHUS.

525. *I. brachiatus* (L.) B. S. P. (*I. coeruleus* Michx.) Dry, sterile ground; frequent.

SCUTELLARIA.

526. *S. lateriflora* L. Damp ground along streams; common.

527. *S. parvula* Michx. Dry prairies and woods; common.

528. *S. galericulata* L. Wet ground; frequent.

AGASTACHE.

529. *A. scrophulariæfolia* (Willd.) Kuntze. (*Lophanthus scrophulariæfolius* Benth.) Common in woods.

NEPETA.

530. *N. cataria* L. Waste ground and open woods; common.

GLECOMA.

531. *G. hederacea* L. (*Nepeta glechoma* Benth.) Moist ground along streams and about houses; common.

PRUNELLA.

532. *P. vulgaris* L. Damp ground everywhere.

PHYSOSTEGIA.

533. *P. virginiana* (L.) Benth. Wet, ground; common.

LEONURUS.

534. *L. cardiaca* L. Waste ground and open woods; common.

STACHYS.

535. *S. palustris* L. Damp ground; abundant.

MONARDA.

536. *M. fistulosa* L. Meadows and open woods; abundant.

HEDEOMA.

537. *H. pulegioides* (L.) Pers. Dry woods; frequent.

538. *H. hispida* Pursh. Abundant on dry prairies.

KŒLLIA.

539. *K. virginiana* (L.) MacM. (*Pycnanthemum lanceolatum* Pursh). Moist meadows, or sometimes in dry ground; abundant.

LYCOPUS.

540. *L. virginicus* L. Wet ground; frequent.

541. *L. americanus* Muhl. (*L. sinuatus* Ell.) Wet ground; abundant.

MENTHA.

542. *M. canadensis* L. Damp ground; abundant.

SOLANACEÆ.

PHYSALIS.

543. *P. virginiana* Mill. (*P. lanceolata* Michx.) Fields and waste ground; abundant.

544. *P. heterophylla* Nees. (*P. virginiana* Gray.) Abundant in cultivated ground.

SOLANUM.

545. *S. nigrum* L. Abundant in cultivated ground.

546. *S. rostratum* Dunal. Locally a troublesome weed, but not generally distributed.

DATURA.

547. *D. stramonium* L. Rich ground, especially about buildings; frequent.

548. *D. tatula* L. With the preceding.

SCROPHULARIACEÆ.

VERBASCUM.

549. *V. thapsus* L. Dry, open woods and pastures; abundant.

LINARIA.

550. *L. linaria* (L.) Karst. (*L. vulgaris* Mill.) In streets and about houses; locally abundant.

SCROPHULARIA.

551. *S. marylandica* L. (*S. nodosa marylandica* Gray). Waste ground and along streams; common.

552. *S. leporella* Bick. With the preceding. It seems difficult to separate these two forms.

CHELONE.

553. *C. glabra* L. Swampy ground; frequent.

PENTSTEMON.

554. *P. grandiflorus* Nutt. Dry, sandy ground; rare.

MIMULUS.

555. *M. ringens* L. Wet ground; abundant.

556. *M. jamesii* T. & G. In seepage springs along the Iowa river; scarce.

GRATIOLA.

557. *G. virginiana* L. Wet ground; frequent.

ILYSANTHES.

558. *I. attenuata* (Muhl.) Small. Muddy ground, about ponds and swamps; common.

VERONICA.

559. *V. anagallis-aquatica* L. (*V. anagallis* L.) Frequent in streams and on muddy shores.
560. *V. serpyllifolia* L. Moist ground; scarce.
561. *V. peregrina* L. Moist fields and waste ground; abundant.

LEPTANDRA.

562. *L. virginica* (L.) Nutt. (*Veronica virginica* L.) Meadows and borders of woods; common.

GERARDIA.

563. *G. aspera* Dougl. Moist prairies; frequent.
564. *G. tenuifolia* Vahl. Dry ground; common.
565. *G. besseyana* Brit. (*G. tenuifolia macrophylla* Benth.) With the preceding, but often on low ground; common.
566. *G. auriculata* Michx. Wet meadows; common.

CASTILLEJA.

567. *C. coccinea* (L.) Spreng. Open woods and meadows, dry or wet ground; frequent. The yellow phase, which is by far the more plentiful, seems always to occur in low meadows, the red on dry, semi-wooded hills; no intermediate form has been noted.
568. *C. sessiliflora* Pursh. Frequent in low prairies.

PEDICULARIS.

569. *P. lanceolata* Michx. Wet meadows; common.
570. *P. canadensis* L. Meadows and wooded slopes; common.

LENTIBULARIACEÆ.

UTRICULARIA.

571. *U. vulgaris* L. Swamps and ponds; common.

PHRYMACEÆ.

PHRYMA.

572. *P. leptostachya* L. Woods and thickets; common.

PLANTAGINACEÆ.

PLANTAGO.

573. *P. major* L. Abundant everywhere.
574. *P. rugelii* Dec. Abundant.
575. *P. lanceolata* L. Local but rapidly spreading.
576. *P. purshii* R. & S. (*P. patagonica gnaphaloides* Gray.) Sandy ground; infrequent.

RUBIACEÆ.

HOUSTONIA.

577. *H. minima* Beck. Local. Several years ago it suddenly appeared in abundance on a dry hill at Iowa Falls, but after two or three seasons vanished as suddenly.

CEPHALANTHUS.

578. *C. occidentalis* L. Swampy thickets; infrequent.

GALIUM.

579. *G. aparine* L. Damp woods; common.
580. *G. boreale* L. Dry, stony ground, mostly on river banks, or sometimes in meadows; locally very abundant.
581. *G. triflorum* Michx. Moist woods; frequent.
582. *G. palustre* L. Common in damp meadows.
583. *G. concinnum* T. & G. Abundant in dry woods.

CAPRIFOLIACEÆ.

SAMBUCUS.

584. *S. canadensis* L. Common in thickets.

VIBURNUM.

585. *V. dentatum* L. Dry thickets; frequent.
586. *V. lentago* L. Frequent in thickets.

TRIOSTEUM.

587. *T. perfoliátum* L. Open woods; common.

SYMPHORICARPOS.

588. *S. occidentalis* Hook. Stony ground in thickets; infrequent.

LONICERA.

589. *L. dioica* L. (*L. glauca* Hill). High rocky banks of streams; common.

590. *L. sullivantii* Gray. Frequent in thickets.

CUCURBITACEÆ.

MICRAMPELIS.

591. *M. lobata* (Mĭchx.) Greĕne. (*Echinocystis lobata* T. & G.) Moist thickets along streams; abundant.

CAMPANULACEÆ.

COMPANULA.

592. *C. rotundifolia* L. Crevices of perpendicular rocks overhanging streams; common.

593. *C. aparinoides* Pursh. Wet meadows and bogs; frequent.

594. *C. americana* L. Moist woods; common.

LEGOUZIA.

595. *L. perfoliata* (L.) Brit. (*Specularia perfoliata* A. D C.) Dry woods; common.

LOBELIA.

596. *L. cardinalis* L. Swampy ground in woods and thickets; scarce.

597. *L. syphilitica* L. Damp ground in meadows and along streams; common.

598. *L. spicata* Lam. Mostly in dry, open ground, sometimes in moist meadows; common.

CICHORIACEÆ.

TRAGOPOGON.

599. *T. pratensis* L. Waste ground; frequent.

TARAXACUM.

600. *T. taraxacum* (L.) Karst. (*T. officinale* Weber.) Abundant everywhere.

601. *T. erythrospermum* Andrz. With the preceding.

SONCHUS.

602. *S. oleraceus* L. Frequent in waste ground.

603. *S. asper* (L.) All. With the preceding, but more common.

LACTUCA.

604. *L. scariola* L. Nearly everywhere in cultivated and waste ground.

605. *L. canadensis* L. Thickets and fields; common.

606. *L. hirsuta* Muhl. Fields and waste ground; common.

HIERACIUM.

607. *H. canadense* Michx. Dry banks and woods or along streams; common.

NABALUS.

608. *N. albus* (L.) Hook. (*Prenanthes alba* L.) Woods and thickets; common.

609. *N. asper* (Michx.) T. and G. (*P. aspera* Michx.) meadows; frequent.

610. *N. racemosus* (Michx.) DC. (*P. racemosa* Michx.) Moist ground in meadows and along railroads; infrequent. Our specimens are very large, eight or nine feet high, with the upper stem, pedicels and bracts shaggy,hirsute,and the lower leaves sessile or nearly so and deeply pinnatifid.

AMBROSIACEÆ.

AMBROSIA.

611. *A. trifida* L. Moist fields and roadsides; too abundant.

612. *A. artemisiæfolia* L. Fields and waste ground; abundant.

613. *A. psilostachya* D C. With the preceding, but scarce.

XANTHIUM.

614 *X. canadense* Mill. Moist fields and along streams; abundant.

COMPOSITÆ.

VERNONIA.

615. *V. fasciculata* Michx. Damp ground; abundant.

EUPATORIUM.

616. *E. maculatum* L. Bogs and wet meadows; common.
617. *E. purpureum* L. Moist woods; common.
618. *E. altissimum* L. Dry, open ground; common.
619. *E. perfoliatum* L. Wet ground; abundant.
620. *E. ageratoides* L. f. Woods; abundant.

KUHNIA.

621. *K. eupatorioides* L. Dry, open ground; abundant

LACINARIA.

622. *L. cylindracea* (Michx.) Kuntze. (*Liatris cylindracea* Michx.) Dry, open ground; common.
623. *L. pycnostachya* (Michx.) Kuntze. (*Liatris pycnostachya* Michx.) Moist meadows; common.
624. *L. scariosa* (L.) Hill. (*Liatris scariosa* Willd.) Dry prairies. Common.

GRINDELIA.

625. *G. squarrosa* (Pursh.) Dunal. Dry hills; scarce.

SOLIDAGO.

626. *S. flexicaulis* L. (*S. latifolia* L.) Stony banks in woods; common.
627. *S. rigidiuscula* (T. &. G.) Port. (*S. speciosa angustata* Gray.) Dry, open ground; frequent.
628. *S. ulmifolia* Muhl. Common in woods.
629. *S. serotina* Ait. Moist or sometimes dry ground; abundant.
630. *S. serotina gigantea* Gray. Thickets; scarce.
631. *S. missouriensis* Nutt. Dry, open ground; frequent;
632. *S. gattinger* Chapm. On dry river bank near Iowa Falls.

633. *S. canadensis* L. Open ground; very abundant.
634. *S. nemoralis* Ait. Dry, open ground; abundant. A strongly marked variety with stems a foot long or less, spreading or nearly prostrate, and inflorescence large in proportion, is common in stony or sterile ground on dry hills; it appears to approach the variety *arenicola* Burgess.
635. *S. rigida* L. Dry ground; abundant.
636. *S. riddellii* Frank. Wet meadows; frequent.

EUTHAMIA.

637. *E. graminifolia* (L.) Nutt. (*Solidago lanceolata* L.) Meadows and roadsides; common.

BOLTONIA.

638. *B. asteroides* (L.) L'Her. Common in swamps.

ASTER.

639. *A. azureus* Lindl. Dry, open ground, or sometimes in moist meadows; common.
640. *A. cordifolius* L. Woods; abundant.
641. *A. patens* Ait. Dry, open ground; common.
642. *A. novæ-angliæ* L. Along streams and roadsides; common.
643. *A. lævis* L. Dry, open ground; common.
644. *A. sericeus* Vent. Dry, open ground; frequent.
645. *A. salicifolius* Lam. Along streams; frequent.
646. *A. paniculatus* Lam. Moist ground along streams; common.
647. *A. paniculatus bellidiflorus* (Willd.) Burgess. With the type.
648. *A. lateriflorus* (L.) Brit. (*A. diffusus* Ait.) Damp, shady or open ground; abundant. Numerous forms occur, probably representing several of the described varieties.
649. *A. multiflorus* Ait. Dry, open ground; abundant.

ERIGERON.

650. *E. philadelphicus* L. River banks; common.
651. *E. annuus* (L.) Pers. Fields and open woods; abundant.

652. *E. ramosus* (Walt.) B. S. P. (*E. strigosus* Muhl.) With the preceding.

LEPTILON.

653. *L. canadense* (L.) Brit. (*Erigeron canadensis* L.) Abundant in fields and waste ground.
654. *L. divaricatum* (Michx.) Raf. (*E. divaricatus* Michx.) Sandy ground; common, locally.

DŒLLINGERIA.

655. *D. umbellata* (Mill.) Nees. (*Aster umbellatus* Mill.) Swampy ground; frequent.

ANTENNARIA.

656. *A. plantaginifolia* (L.) Rich. Dry prairies; abundant.

POLYMNIA.

657. *P. canadensis* L. Damp woods; scarce.

SILPHIUM.

658. *S. perfoliatum* L. Along streams and in thickets; common.
659. *S. integrifolium* Michx. Roadsides; infrequent.
660. *S. laciniatum* L. Prairies; common.

PARTHENIUM.

661. *P. integrifolium* L. Meadows; common.

HELIOPSIS.

662. *H. scabra* Dunal. Roadsides and thickets; abundant.

RUDBECKIA.

663. *R. triloba* L. Woods and thickets; common.
664. *R. subtomentosa* Pursh. Along streams; infrequent.
665. *R. hirta* L. Open woods and meadows; abundant.
666. *R. laciniata* L. Damp ground along streams; common.

RATIBIDA.

667. *R. pinnata* (Vent.) Barnh. (*Lepachys pinnata* T. & G.) Dry prairies and roadsides; abundant.
668. *R. columnaris* (Sims) D. Don. (*L. columnaris* T. & G.) With the preceding, but rare.

BRAUNERIA.

669. *B. pallida* (Nutt.) Brit. (*Echinacea angustifolia* DC.) Dry, open ground; common.

HELIANTHUS.

670. *H. annuus* L. Occasionally escaped.
671. *H. petiolaris* Nutt. Waste ground; rare.
672. *H. scaberrimus* Ell. (*H. rigidus* Desf.) Prairies and roadsides; abundant.
673. *H. grosse-serratus* Martens. Moist meadows and fields; common.
674. *H. strumosus* L. Dry banks and thickets; abundant.
675. *H. tuberosus* L. Borders of fields and woods; common.

COREOPSIS.

676. *C. tinctoria* Nutt. Near railroads; scarce.
677. *C. palmata* Nutt. Dry banks and prairies; common.

BIDENS.

678. *B. laevis* (L.) B. S. P. (*B. chrysanthemoides* Michx.) About swamps and along streams; abundant.
679. *B. connata* Muhl. With the preceding; common.
680. *B. frondosa* L. Moist, cultivated or waste ground; abundant.
681. *B. trichosperma* (Michx.) Brit. var. *tenuiloba* (Gray) Brit. (*Coreopsis trichosperma* Michx. var. *tenuiloba* Gray). Swampy meadows; locally, abundant.

HELENIUM.

682. *H. autumnale* L. Wet meadows and along streams; abundant.
683. *H. tenuifolium* Nutt. One specimen, in moist, sandy ground.

DYSODIA.

684. *D. papposa* (Nutt.) Hitch. Roadsides; not generally distributed.

ACHILLEA.

685. *A. millefolium* L. Prairies and pastures; abundant.

ANTHEMIS.

686. *A. cotula* L. Waste ground about buildings; abundant.

CHRYSANTHEMUM.

687. *C. leucanthemum* L. Waste ground; rare.

TANACETUM.

688. *T. vulgare* L. Sometimes escaped to roadsides.

ARTEMISIA.

689. *A. caudata* Michx. Dry, sandy or rocky soil common.

690. *A. dracunculoides* Pursh. Waste, sandy ground one specimen.

691. *A. biennis* Willd. Waste ground, especially about houses; common.

692. *A. serrata* Nutt. Borders of fields and meadows; common.

693. *A. gnaphalodes* Nutt. (*A. ludoviciana* Nutt.) Prairies; common.

ERECHTITES.

694. *E. hieracifolia* (L.) Raf. Woods; abundant locally.

MESADENIA.

695. *M. atriplicifolia* (L.) Raf. (*Cacalia atriplicifolia* L.) Moist woods; scarce.

696. *M. tuberosa* (Nutt.) Brit. (*C. tuberosa* Nutt.) Moist or sometimes dry open ground; common.

SENECIO.

697. *S. aureus* L. Wet meadows or dry, sterile hills; common.

698. *S. palustris* (L.) Hook. Swamps and wet fields; frequent.

ARCTIUM.

699. *A. lappa* L. Abundant; especially about houses.

CARDUUS.

700. *C. lanceolatus* L. (*Cnicus lanceolatus* Hoffm.) Abundant in open ground.
701. *C. altissimus* L. (*C. altissimus* Willd.) Fields and roadsides; common.
702. *C. canescens canescens* Nutt. (*C. undulatus* var. *canescens* Gr.
703. *C. discolor* (Muhl.) Nutt. (*C. altissimus discolor* Gray.) With the preceding; common.
704. *C. arvensis* L. (*C. arvensis* Hoffm.) Becoming quite common.

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